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ABSTRACT

Problems and practices in financing and managing research equipment are assessed, based on visits to 23 college, government, and industry laboratories and meetings with over 500 scientists, and college, government, and industry representatives. The following concerns are addressed: possible changes in federal/state laws, regulations, or policies to improve the acquisition, management, and use of academic research equipment; ways colleges might improve the way they acquire, manage, and use research equipment; possible revisions to tax incentives for industry donations of research equipment to colleges; and alternative methods of direct federal funding of research equipment. Recommendations cover the federal government, the states, the universities, debt financing by universities, and private support for equipment. Information is included on: loan subsidy programs, federal instrumentation programs, regulations for 10 states, and 20 state statutes authorizing bonds to fund college facilities. Appendices provide examples of debt financing and equipment donations, information on debt financing instruments, and data on 1953-1983 research and development expenditures at colleges by source of funds, and 1982 and 1983 fund expenditures for research equipment at colleges by science/engineering field and source of funds. (SW)

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Financing and Managing University Research Equipment

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Financing and Managing University Research Equipment

Association of American Universities
National Association of State Universities
and Land-Grant Colleges
Council on Governmental Relations

Washington, D.C. 1985

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Early drafts of material were prepared for the Steering Committee's review and discussion by our research team, consultants, and staff. Robert Bock, David Litster, and Julie Norris drafted material on the universities' role in the acquisition and management of research equipment. Milton Goldberg prepared the analysis of federal regulatory issues. Michael Goldstein of Dow, Lohnes, and Albertson drafted material on the state role in acquiring and managing research equipment. The chapters on debt financing and private support of academic research equipment are based on a background paper prepared for the Steering Committee by Coopers & Lybrand.

As our work progressed, members of the Steering Committee critically reviewed drafts of the report chapters, all of which were then discussed at committee meetings. We also benefited from the thoughtful reviews and substantive contributions to the report by Robert Clodius and John Crowley.

Gwendolyn McCutcheon provided expert administrative and secretarial assistance throughout the study. She handled all administrative details, helped arrange meetings, and was centrally involved in preparing the manuscript for production. Joyce Madancy helped with many research tasks. The fine editorial work of Kenneth Reese was invaluable in the final stages of report preparation.

Richard A. Zdanis, Chairman
Steering Committee

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Summary and Recommendations

Contemporary science and technology are inconceivable without the array of instruments and other research equipment available today. Recent years, however, have seen steady erosion of our universities' ability to acquire and maintain equipment that qualifies as state of the art--the best generally available. Without this new equipment, advances in many scientific disciplines cannot occur. The situation has reached the point where it threatens the strength of the nation's research enterprise and the quality of education of new scientists and engineers.

The project summarized here was designed to seek ways to ensure that the funds available for scientific equipment in universities are used at maximum efficiency. We examined federal and state regulations and practices, management practices in universities, and sources and mechanisms of funding. We reached the following broad conclusions:

Many actions can be taken that clearly would enhance efficiency in the acquisition, management, and use of research equipment by universities, and they are specified in our recommendations. The overall problem is so large, however, that it cannot be properly addressed without substantial, sustained investment by all sources—federal and state governments, universities, and the private sector.

SOURCE OF THE PROBLEM

The situation has been documented in a succession of studies dating from the early 1970s. The most recent and most comprehensive study is the National Science Foundation's National Survey of Academic Research Instruments, covering the years 1982-1983. Newly published results of the survey show in part that:

- Of the university department heads surveyed, 72 percent reported that lack of equipment was preventing critical experiments.
- Universities' inventories of scientific equipment showed that 20 percent was obsolete and no longer used in research.
- Of all instrument systems in use in research, 22 percent were more than 10 years old.
- Only 52 percent of instruments in use were reported to be in excellent working condition.
- Of university department heads surveyed, 49 percent rated the quality of instrument-support services (machine shop, electronics shop, etc.) as insufficient or nonexistent.

Contributory Trends

Such difficulties stem from several interrelated trends. As scientific instruments have grown steadily more powerful and productive, their initial costs have significantly outpaced the general rate of inflation. One industrial laboratory, for example, found that the cost of keeping its stock of research equipment at the state of the art rose 16.4 percent per year during 1975-1981, while the consumer price index rose 9.9 percent per year. The growing capabilities of equipment also entail higher costs for operation and maintenance. The rapid pace of development, moreover, has shortened the technologically useful life of equipment; instruments today may be superseded by more advanced models in five years or less. And for more than 15 years, the funds available from all sources have failed consistently to reflect the rising costs and declining useful lifetimes of academic research equipment.

Research project grants, the leading source of academic research equipment, have only slightly outpaced inflation in recent years. Individual grants averaged about $94,000 at the National Science Foundation (NSF) in 1985 and $133,000 at the National Institutes of Health (NIH). Such grants can accommodate instruments of only modest cost. Benchtop equipment priced at $50,000 or more is common, however, and research in a number of fields is relying increasingly on equipment that costs from $100,000 to $1 million.

Trends in funding of scientific equipment in universities have long been dominated by federal spending, which accounted for 54 percent of the equipment in use in 1982-1983; the universities themselves are the next most important source of support and provided 32 percent of such funding. States directly funded 5 percent of the cost of the equipment in use in 1982-1983, individuals and nonprofit organizations funded 5 percent, and industry funded 4 percent. Federal funding of academic research--including the associated equipment--grew at an average annual rate of 15.7 percent, in constant dollars, during 1953-1967, but the rate fell to 1.6 percent during 1968-1983.

Besides its role in support of research, the government was a major contributor to the universities' massive capital expansion of the 1950s and 1960s, which included substantial amounts of scientific equipment. Again, however, the rate of federal investment turned downward. The government's annual spending on academic R&D facilities and equipment, in constant dollars, fell some 78 percent during 1966-1983.

RESPONSES TO THE PROBLEM

Both academic and federal officials responded to essentially level funding by supporting people over investment in capital equipment. The fraction of research-project support allocated to permanent university equipment by the National Institutes of Health declined from 11.7 percent in 1966 to an estimated 3.1 percent in 1985. At the National Science Foundation the fraction fell from 11.2 percent in 1966 to an average of 7.1 percent during 1969-1976. The federal mission agencies' support for research equipment declined similarly, although exact data are not available.

Efforts to ease the universities' serious difficulties with scientific equipment began to appear in the early 1980s. NSF increased its investment in academic equipment from 11 percent of its university R&D budget in 1978 to an estimated 17.5 percent in 1985. The Department of Defense launched a special five-year university instrumentation program, totaling $150 million, which is projected to run through 1987. The Department of Energy began a special $30 million program scheduled to end in 1988. The federal and state governments adopted tax incentives designed to encourage contributions of equipment by its manufacturers. State governments began to increase their funding of equipment for state colleges and universities and have initiated a range of development activities designed in part to attract industrial support for R&D in their universities.

The expanded federal investments were the result, in part, of the efforts of the Interagency Working Group on University Research Instrumentation, which was organized in mid-1981 to focus high-level agency attention on the university instrumentation problem. Its members were senior officials drawn from each of the six major agencies supporting research in universities--the National Science Foundation, the National Institutes of

Health, the National Aeronautics and Space Administration, and the Departments of Agriculture, Defense, and Energy.

BACKGROUND OF THE STUDY

Although these initiatives are welcome, they clearly are not sufficient. Officials in academe and government agree that the equipment problem is critical and steadily growing and that ways to use existing resources more efficiently must be explored. In July 1982 at the request of the Interagency Working Group, the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the Council on Governmental Relations convened an ad hoc planning committee to consider whether a special effort was needed to address the following questions:

- Could changes be made in federal or state laws, regulations, or policies that would enhance the efficiency of acquisition, management, and use of academic research equipment?
- What more can universities do to improve the way they acquire, manage, and use research equipment?
- Does debt financing hold significant untapped potential for universities as a means of acquiring new research equipment?
- Can present tax incentives for the donation of research equipment to universities be revised to increase support from industry?
- Are there alternative methods of direct federal funding of research equipment that would yield a better return on the federal investment?

The resulting analysis was carried out jointly by the three associations with funding from the six federal agencies and the Research Corporation. Substantive direction for the study was provided by a seven-member Steering Committee chaired by Richard Zdanis, Vice Provost of Johns Hopkins University. Much of the field research was done by a three-member team: Robert Bock, Dean of the Graduate School at the University of Wisconsin; David Litster, Director of the Center for Materials Science and Engineering at MIT; and Julie Norris, Assistant Provost of the University of Houston. This team visited 23 universities and governmental and industrial laboratories; they met with more than 500 faculty investigators, department chairmen, research and service center directors, deans and chief administrators, or the functional equivalents in government and industry. (A list of the places visited is appended to this summary.) The team and the firm of Coopers & Lybrand each produced background reports for the project.

RECOMMENDATIONS

The actions recommended below, as we stated at the outset, would clearly enhance efficiency in the acquisition, management, and use of academic research equipment. We would like to emphasize, however, that even if all these recommendations are acted upon, the universities' equipment needs are so large that they cannot be met without substantial increases in funding. Modernization, moreover, cannot be a one-time effort. Continuing investment will be required based on the recognition that laboratories in many fields of science have to be reequipped at intervals of five years or less. The universities, the states, and industry must share with the federal government the responsibility for modernization and long-term maintenance of the quality of scientific equipment at the nation's universities.

The recommendations that follow appear in the topical order employed in the full report: the federal government, the states, the universities, debt financing by universities, and private support for equipment.

The Federal Government

The federal government has been the major funder of research equipment in universities during the past four decades. Current federal funding mechanisms, however, do not comprise adequate means of regularly replacing obsolete or worn-out equipment with state-of-the-art equipment. Regulatory and procedural difficulties complicate the problem.

We recommend...

1. **That the heads of federal agencies supporting university research issue policy statements aimed at removing barriers to the efficient acquisition, management, and use of academic research equipment.** Few federal regulations, as written, contribute directly to the equipment problem. Inconsistent interpretation of regulations by federal officials, however, complicates the purchase, management, and replacement of research equipment and leads to unnecessarily conservative management practices at universities. Desirable actions are summarized in the recommendations below.

2. **That federal agencies more adequately recognize and provide for the full costs of equipment, including operation and maintenance, space renovation, service contracts, and technical support by...**

...providing these costs in project grants and contracts or ensuring that recipients have provided them.

...accepting universities' payment of costs such as installation, operation, and maintenance as matching funds on programs that require matching contributions by universities.

3. **That federal agencies adopt procedures that facilitate spreading the cost of more expensive equipment charged directly to research-project awards over several award-years and allow the cost and use of equipment to be shared across award and agency lines.** Individual research-project grants and contracts normally can accommodate equipment of only modest cost. Investigators, moreover, have difficulty combining funds from awards from the same or different agencies to buy equipment.

4. **That federal auditors permit universities to recover the full cost of nonfederally funded equipment from federal awards when they convert from use allowance to depreciation.** Office of Management and Budget (OMB) Circular A-21 permits such conversion as well as recovery of full cost. Auditors of the Department of Health and Human Services, however, permit recovery only as if the equipment were being depreciated during the time it was in fact covered by the use allowance. This practice, in effect, denies recovery of full cost.

5. **That the Office of Management and Budget make interest on equipment funds borrowed externally by universities unequivocally an allowable cost by removing from OMB Circular A-21 the requirement that agencies must approve such charges.** Interest on externally borrowed funds has been a permissible cost since 1982 at the discretion of the funding agency, but agencies have shown significant reluctance to permit it. The perception of inability to recover interest costs may lead university officials to decide against seeking debt financing for equipment.

6. **That all federal agencies vest title to research equipment in universities uniformly upon acquisition, whether under grants or contracts.** Federal regulations on title to equipment vary among agencies, and such variability inhibits efficient acquisition, management, and use of equipment. Without assurance of title, for example, investigators hesitate to combine university funds with federal funds to acquire an instrument not affordable by a single sponsor.

7. **That the Office of Management and Budget make federal regulations and practices governing management of equipment less cumbersome by...**

...setting at $10,000 the minimum level at which universities must screen their inventories before buying new equipment and, above that minimum, permitting universities and agencies to negotiate different screening levels for different circumstances.

...raising the capitalization level for research equipment to $1,000 in OMB Circulars A-21 (now at $500) and A-110 (now at $300) and giving universities the option of capitalizing at different levels.

8. **That the Department of Defense eliminate its requirement that the inventory of the Defense Industrial Plant Equipment Center (DIPEC) be screened for the availability of specialized scientific equipment requested by universities before new equipment is purchased.** The descriptions of equipment in the DIPEC inventory do not permit a federal property officer to determine whether a scientific instrument in the inventory is an adequate substitute for the one requested. Hence, the requirement for screening is wasteful for both universities and the government.

9. **That other federal agencies adopt the NIH and NSF prior approval systems.** Purchases of equipment with federal funds ordinarily must be approved in advance by the sponsoring agency. Purchases can be approved by the university, however, under the NIH Institutional Prior Approval System and the NSF Organizational Prior Approval System. These systems markedly improve speed and flexibility in acquiring equipment.

The States

State governments act as both funder and regulator in regard to academic research equipment, and conflict between these roles is inherent to a degree in the relationship between the states and their public universities. Still, we believe that in many cases the states could combine these broad roles more rationally and could otherwise help to ease the schools' difficulties with research equipment.

We recommend...

1. **That states assess the adequacy of their direct support for scientific equipment in their public and private universities and colleges relative to support from other sources and the stature of their schools in the sciences and engineering.** The states cannot displace the federal government as the major funder of academic research equipment, but judicious increases on a highly selective basis could be extremely beneficial to the scientific stature of states while simultaneously increasing the effectiveness of funds available from federal and industrial sources.

2. **That states grant their public universities and colleges greater flexibility in handling funds.** Desirable provisions would permit schools to transfer funds among budget categories, for example, and to carry funds forward from one fiscal period to the

next. Greater flexibility would not only improve the universities' ability to deal with the problems of research equipment, it would also be likely to provide direct savings in purchasing and would free academic administrators to discharge their responsibilities more efficiently.

3. **That states examine the use of their taxing powers to foster academic research and modernization of research equipment.** Tax benefits available under the federal Internal Revenue Code are also available in 34 states whose tax codes automatically follow the federal code. Relatively few states, however, have adopted tax benefits designed to fit their particular circumstances.

4. **That states revise their controls on procurement to recognize the unusual nature of scientific equipment and its importance to the research capability of universities.** Scientific equipment often is highly specialized. Instruments that have the same general specifications but are made by different vendors, for example, may have significantly different capabilities. The differences, furthermore, may be discernible only by experts in the use of the equipment. Desirable revisions in state controls would exempt research equipment from purchasing requirements designed for generic equipment and supplies, such as batteries and cleaning materials; would vest purchasing authority for research equipment in individual colleges and universities; and would not apply rules beyond those already mandated by the federal government.

5. **That states consider revising their controls on debt financing of scientific equipment at public colleges and universities to permit debt financing of equipment not part of construction projects, recognize the relatively short useful life of scientific instruments, and relieve the one- and two-year limits on the duration of leases.**

The Universities

The universities' ability to acquire and manage research equipment efficiently is affected by their individual circumstances, their traditionally decentralized authority, the individual project-award system that funds much of the equipment, and state and federal regulations. Within this context, however, we have identified a number of management practices that warrant more widespread use.

Our findings indicate that universities would benefit from stronger efforts to improve their internal communications. Moreover, our recommendations on the whole imply a need for a more centralized approach than is now the general practice in universities' management of research equipment. We note that other developments, including the universities' growing interest in debt financing and strategic planning, also point toward more centralized management.

We recommend...

1. **That universities more systematically plan their allocation of resources to favor research and equipment in areas that offer the best opportunities to achieve distinction.** Such strategic planning should involve participation by both administrators and faculty. The process may well call for hard decisions, but we believe that they must be made to optimize the use of available funds.

2. **That universities budget realistically for the costs of operating and maintaining research equipment.** These costs impose serious and pervasive problems, and failure to plan adequately for full costs when buying equipment is widespread as well. Full costs include not only operation and maintenance, but space renovation, service contracts, technical support, and the like. Maintenance is particularly troublesome. Hourly user charges are commonly assessed to cover the salaries of support personnel and the costs of maintenance, but are difficult to set optimally and are rarely adequate.

3. **That investigators and administrators at universities seek agency approval to spread the cost of expensive equipment charged directly to research-project awards over several award years.** As noted in Recommendation 3 under the Federal Government, individual research grants and contracts cannot normally accommodate costly equipment, and this problem would be eased by spreading costs over several years.

4. **That universities act to minimize delays and other problems resulting from procurement procedures associated with the acquisition of research equipment.** To be most effective, the procurement process should be adapted to the specialized nature of research equipment, as opposed to more generic products. Similarly, specialized purchasing entities or individuals would facilitate timely acquisition of equipment at optimum cost. Also beneficial would be formal programs designed to inform purchasing personnel and investigators of the needs and problems of each.

5. **That universities consider establishing inventory systems that facilitate sharing.** One such system is the basis of the research equipment assistance program (REAP) at Iowa State University. The REAP inventory includes only research equipment. REAP may not be cost effective for all universities, but most should find elements of it useful.

6. **That universities use depreciation rather than a use allowance to generate funds for replacing equipment, providing that**

they can negotiate realistic depreciation schedules and dedicate the funds recovered to equipment. Universities can use either method, but rates of depreciation are potentially higher--and so recover costs more rapidly--than the use allowance (6 2/3 percent per year) because they can be based on the useful life of the equipment. Both methods, however, add to indirect costs, and neither can be used for equipment purchased with federal funds.

7. **That universities seek better ways to facilitate the transfer of research equipment from investigators or laboratories that no longer need it to those that could use it.** Faculty at most schools have no incentive to transfer equipment, excepting the need for space, and every incentive to keep it in case it might be needed again. Some systematic mechanism for keeping faculty well informed of needs and availability of equipment would be useful.

Debt Financing of Research Equipment

Universities traditionally have used tax-exempt debt financing to pay for major facilities and lately have been using the method to some extent to buy research equipment. A number of financing methods can be adapted to the special characteristics of such equipment, but whatever the method, such financing competes with other university needs for debt. Debt financing imposes risk on the university as a whole, and so implies a shift from decentralized toward centralized authority.

We recommend...

1. **That universities explore greater use of debt financing as a means of acquiring research equipment, but with careful regard for the long-term consequences.** Universities vary widely in their use of debt financing, but a universal concern is the need for a reliable stream of income to make the debt payments. It should also be recognized that the necessary commitment of institutional resources, regardless of the purpose of the debt financing, erodes the university's control of its future, in part by reducing the flexibility to pursue promising new opportunities as they arise. Debt financing also increases the overall cost of research equipment to both universities and sponsors of research.

2. **That universities that have not done so develop expertise on leasing and debt financing of equipment.** This expertise should include the ability to determine and communicate the true costs of debt financing and should be readily accessible to research administrators and principal investigators. The increasing complexity of tax-exempt debt financing, the many participants,

the necessary legal opinions, and the various political and/or corporate entities associated with debt financing make it essential that universities fully understand the marketplace.

Private Support

The effects of the Economic Recovery Tax Act (ERTA) of 1981 on corporate spending on R&D and corporate contributions of research equipment to universities are not clear, for several reasons: the act has been in effect only since August 1981, its effects are entangled with other economic variables in a complex manner, and the uncertain future of the R&D tax credit, which is scheduled to expire at the end of 1985, may have skewed corporate response to it (the equipment donation provision is permanent). Nevertheless, the consensus appears to be that ERTA, suitably modified, should indeed spur technology, in part by fostering support for academic research and scientific equipment. We agree with this view.

We recommend...

1. **That industry take greater advantage of the tax benefits provided by the Economic Recovery Tax Act (ERTA) of 1981 for companies that donate research equipment to universities and fund academic research.** Universities' experiences with industry indicate that company officials may not be fully aware of the benefits available, although company tax specialists generally are well informed.
2. **That universities seek donations of research equipment more aggressively by developing strategies that rely in part on the tax benefits available to donors.** Sound strategies would stress both federal and state tax benefits as well as other important benefits to both donor and recipient.
3. **That Congress modify ERTA so that...**

...equipment qualified for the charitable donation deduction include computer software, equipment maintenance contracts and spare parts, equipment in which the cost of parts not made by the donor exceeds 50 percent of the donor's costs in the equipment, and used equipment that is less than three years old. Computers are properly viewed as computing systems, which are incomplete without software. Maintenance of scientific equipment is costly to the point where universities have declined donations of equipment because they could not afford to maintain it. Makers of sophisticated equipment rely primarily on their technological knowledge, not their ability to make parts. Thus the limit on parts from outside suppliers is unrealistic, provided that the manufacturer is in fact in the business of developing and making scientific equipment.

...the provisions on the R&D tax credit are made permanent, with revision to create an additional incentive for companies to support basic research in universities. Equipment acquired under research contracts qualifies for the credit, but ERTA currently provides the same incentive for companies to contract for research in academe as for research by other qualified organizations.

...the social and behavioral sciences are made qualified fields of academic research in terms of the equipment donation deduction and the R&D tax credit. The social and behavioral sciences contribute to the application and utilization of science and technology, and they rely increasingly on research instrumentation.

...qualified recipients of equipment donations and R&D funding, in terms of ERTA tax credits, include research foundations that are affiliated with universities but remain separate entities. Some state universities have established such foundations to receive and dispose of donated equipment because they cannot dispose of it themselves without legislative consent.

These actions, we are convinced, would yield material benefits in the acquisition and management of research equipment by universities. The rationale for them here is necessarily brief. Much fuller background will be found in the five chapters of the full report, where these recommendations also appear.

Site Visits

UNIVERSITIES

Public:
Colorado State University
Georgia Institute of Technology
Iowa State University
North Carolina State University
Texas A&M University
University of Illinois, Urbana
University of Minnesota
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Stanford Synchrotron Radiation Laboratory

STATE AGENCIES

North Carolina Board of Science and Technology

1

Academic Research Equipment: The Federal Role

BACKGROUND AND TRENDS

The federal government has been the major funder of research and development and the associated equipment in U.S. universities during the four decades following World War II. The government has always recognized the utility of science and technology, but, except for agricultural research, funded relatively little research in universities before 1940.[1] The massive postwar commitment sprang from the success of science in the war effort and its consequent promise for the well-being of the nation in peacetime. Federal funding of academic research drew further impetus from the launching of Sputnik 1, the first earth-orbiting satellite, by the Soviet Union in October 1957. The federal commitment is by now well established, although the rate of increase of funding declined sharply after the late 1960s.

The government supports the acquisition and operation of research equipment in universities in a number of ways. These support mechanisms are implemented by federal regulations and agency guidelines designed to ensure accountability for the public funds expended and proper use of equipment. The regulations are administered by the sponsoring agencies and the universities. The universities' compliance with the regulations is monitored by the Audit Agency of the Department of Health and Human Services, which handles about 95 percent of all colleges and universities, and the Defense Contract Audit Agency in the Department of Defense. The regulatory structure in some measure inhibits the universities' freedom of action, but the importance of federal funds to research and graduate education causes both partners to search for accommodations.

Funding Trends

Federal funding of academic research and development is the best available indicator of trends in federal funding of academic research equipment (trend data specific to equipment do not exist). In constant 1972 dollars, federal funding grew at an average annual rate of 15.7 percent during 1953-1967 and 1.6 percent during 1968-1983 (Figure 1 and Appendix A). Federal funding in current dollars was $4.96 billion in 1983, when it comprised 64 percent of total spending for academic R&D (Figure 2); state and local governments accounted for 7 percent, industry for 5 percent, the universities themselves for 16 percent, and all other sources for 8 percent.

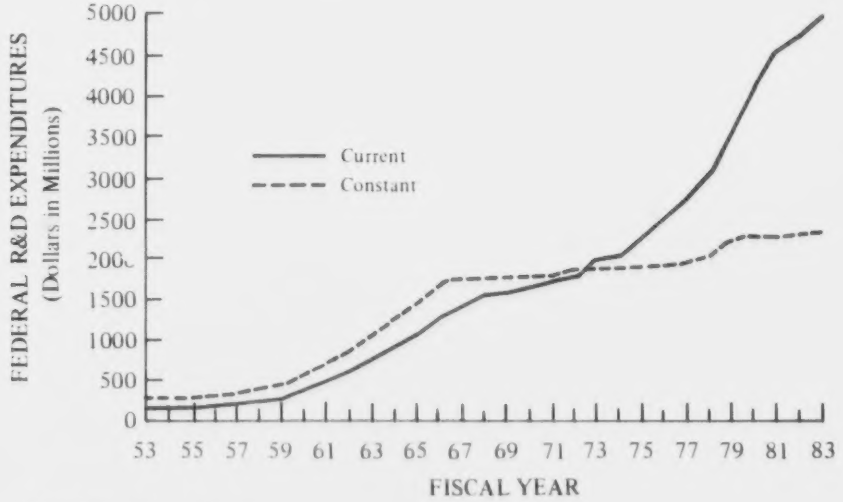
Recent data on research equipment alone show a similar pattern. The federal government accounted for 65 percent of total spending for academic research equipment in 1982 and 63 percent in 1983. Nonfederal sources of funding increased by 14.5 percent between 1982 and 1983, while federal funding of academic research equipment grew by only 2.4 percent (Appendix B).

A significant source of research equipment was the building boom of the 1960s in academic R&D facilities. The institutions had been expanding since the early 1950s in response to a national need to cope with the postwar growth in enrollments. The launching of Sputnik led the federal government to invest heavily in expanding their capacity for graduate education and research in the sciences and engineering. The boom tapered off in the late 1960s. Spending on academic R&D facilities and equipment, currently about $1 billion per year, has been relatively flat since 1968 in current dollars and, in constant dollars, declined 78 percent during 1966-1983 (Figure 3). The federal share of the total, meanwhile, declined from 32 percent in 1966-1968 to 12 percent in 1983. Federal obligations for academic R&D plant have been relatively flat since 1973 in current dollars, averaging about $38 million per year (Figure 4); in constant dollars the obligations fell 93 percent during 1966-1983 and 64 percent during 1973-1983.

The Equipment Problem

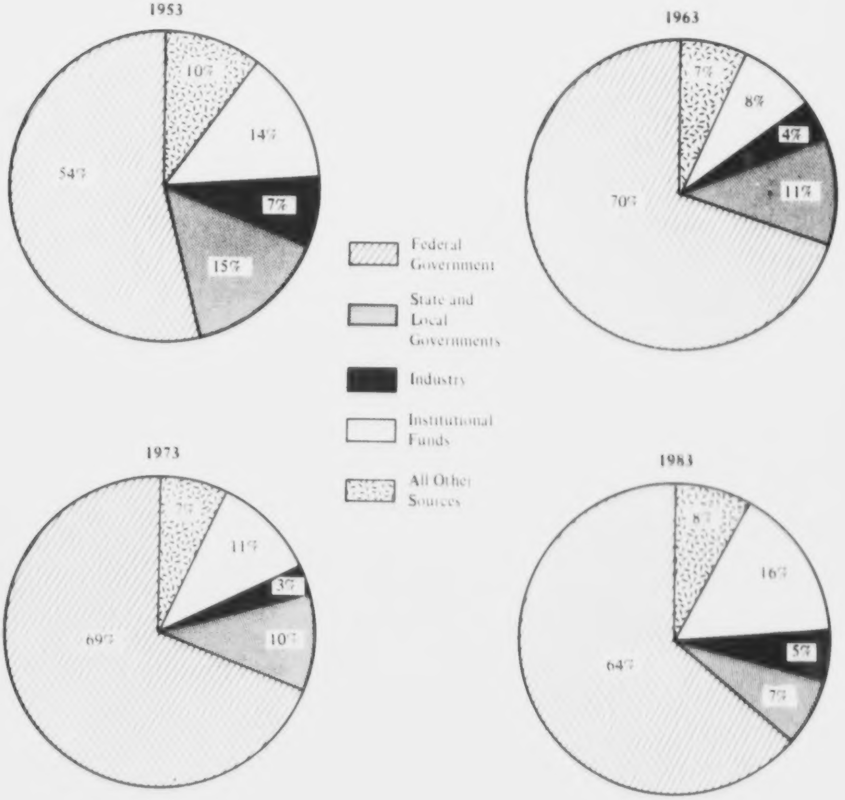
The trends of the past 15 years or so in federal funding of academic R&D and facilities are significant elements of the universities' serious problem with research equipment. The problem is usually stated as a shortage of state-of-the-art equipment, but the costs of operation and maintenance are serious difficulties as well.

FIGURE 1
Federal R&D Expenditures at Universities and Colleges
Fiscal Years 1953-1983



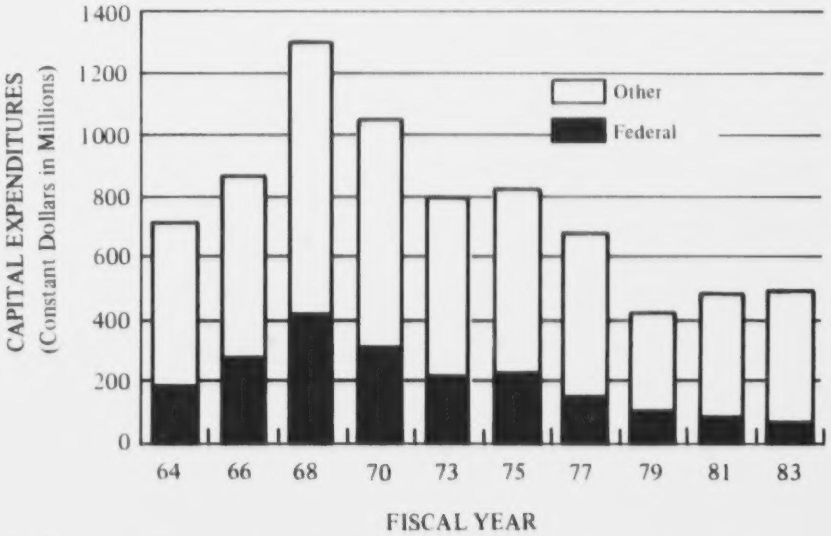
SOURCE: Appendix A.

FIGURE 2
Percentage of Total R&D Expenditures at Universities and Colleges by Source



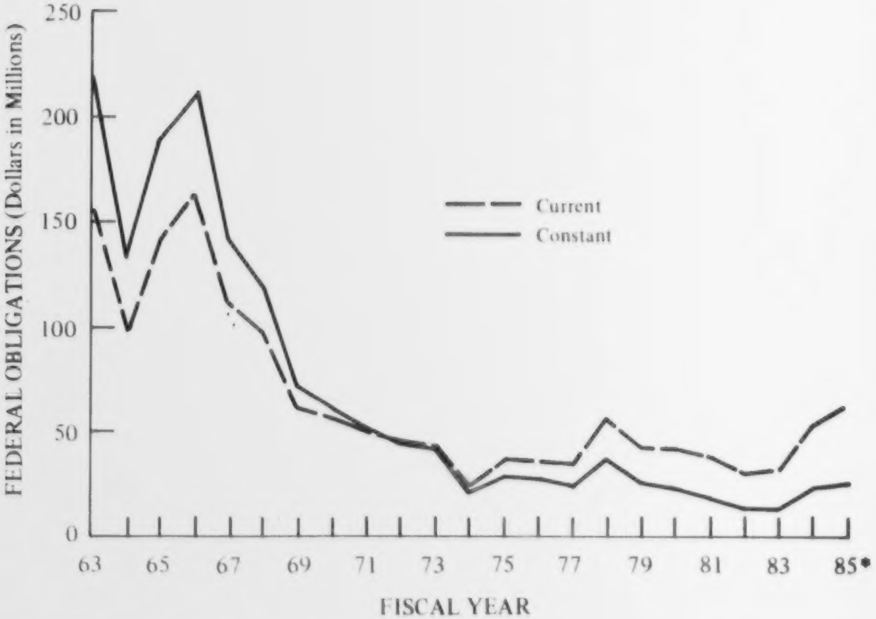
SOURCE: Appendix A.

FIGURE 3
Capital Expenditures for Academic Scientific and Engineering Facilities and Equipment for Research, Development, and Instruction
Fiscal Years 1964-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

FIGURE 4
Federal Obligations for R&D Plant to
Universities and Colleges
Fiscal Years 1963-1985



SOURCE: Division of Science Resources Studies, National Science Foundation.
NOTE: Figures for 1984 and 1985 are estimates.*

The situation has been examined in studies that date back to 1971.[2-8] These studies give only crude estimates of the cost of updating academic research equipment nationwide,[9] but the reality of the problem is not in question. According to the National Science Foundation (NSF) National Survey of Academic Research Instruments, 72 percent of department heads reported in 1982-1983 that lack of equipment was preventing critical experiments. NSF grantees in a second study were asked to rank six factors for importance in spending university money to improve research.[10] They ranked instrumentation first more often than any other factor and facilities second. The other factors were numbers of positions and pay for faculty and for graduate students.

The remarkable power of modern scientific instruments, ironically, is part of the problem--as equipment has grown steadily more sophisticated, its cost has outrun the overall rate of inflation. The most powerful versions of some kinds of equipment, moreover, now cost so much that the government funds them only for use in national or regional facilities as opposed to exclusive use by one university or one investigator. The trend is evident in a major industrial laboratory's comparison of the cost of sustaining state of the art in equipment in 1975 and 1981.[11] The study was based on 126 items of equipment worth some $13.5 million in 1981. Costs were found to have climbed 16.4 percent per year during 1975-1981; the consumer price index during the same period rose 9.9 percent per year.

Start-Up Costs

The rapid evolution of equipment in power and cost has especially affected start-up costs for faculty investigators. A midwestern university, for example, equipped two new investigators with comparable experience and interests in chemistry, one in 1970 and one in 1979.[12] The investigator equipped in 1970 needed dedicated equipment costing $8,000 and access to departmental equipment costing $116,500. For the investigator equipped in 1979, these figures had climbed to $43,850 and $741,000, equivalent to an annual increase of 22 percent for laboratory instruments and 23 percent for departmental instruments. Without the costlier, more powerful equipment, however, the investigator equipped in 1979 would not have realized his potential in contributing to his field of research.

The experience was typical of the 1970s, and the costs have continued to rise in the 1980s. Chemistry and other fields where investigators traditionally work with personal, bench-top equipment have become capital intensive. The cost of equipment and facilities needed for a new faculty member today may easily surpass the size of the endowment needed to pay his salary.[13]

People Versus Equipment

During this period of rising costs for research equipment, federal funding agencies have displayed growing reluctance to pay for it at the expense of the operating costs of research. The usual preference is to fund people at the expense of equipment. The fraction of research-project support allocated to permanent laboratory equipment by the National Institutes of Health (NIH) declined from 11.7 percent in 1966 to an estimated 3.1 percent in 1985. At NSF, the fraction fell from 11.2 percent in 1966 to an average of 7.1 percent during 1969-1976. During the past few years, however, the agencies have been paying more attention to equipment (see below). NSF support, for example, is expected to rise to an estimated 17.5 percent of total research-project support for fiscal year 1985.

FUNDING MECHANISMS

Federal funds for academic research equipment for some years have largely been built into the support for the work in which the equipment is to be used. An investigator's research proposal, for example, may request funds for new equipment needed as well as for the research itself. Several agencies recently have started direct funding programs specifically for equipment in response to the universities' growing problem with it. Nevertheless, the diverse array of traditional funding mechanisms remains the leading source of federal support for academic research equipment. These mechanisms have contributed immensely to the strength of U.S. science. Some of their characteristics, and the associated regulations, however, tend to complicate the acquisition, operation, and maintenance of equipment.[14]

Individual Research Projects

Almost half of federal support for research in universities comprises grants or contracts for individual research projects to be conducted by one or a few investigators. Awards are made on the basis of proposals submitted by investigators and evaluated as a rule by scientific and technical review. Proposals are judged comparatively as well as on their own merits. This competitive approach is designed to ensure that the available funds support the most worthy research. Currently, a proposal has a 30 to 50 percent chance of succeeding.*

Research-project grants and contracts are awarded to the investigator's university. The term is rarely more than three years, and the amount rarely exceeds $200,000 per year. Project grants awarded by NIH in 1985, for example, averaged $133,000; at NSF they averaged about $94,000 (Figure 5). The amounts of the awards generally have kept up with inflation, but research itself has become more capital intensive, and that capital expense is often reflected in university investment in equipment and facilities.[13]

The strengths and weaknesses of the research-project system have been studied at length.[14] The size of the awards, for example, permits many investigators to be supported and many agencies to fund research of interest to them. On the other hand, the number and relatively short terms of awards create a heavy administrative task for agencies, universities, and researchers. Active scientists may need three or four grants to support their programs and so devote much time to competing for funds from federal and other sources.

As the costs of equipment have outpaced inflation, project awards increasingly have accommodated equipment of only modest cost. Funds generally cannot be carried forward or backward between grant years to acquire equipment too costly to buy from one year's funds. Further, individual scientists have difficulty combining funds from more than one award to acquire equipment; similarly, several scientists usually find it difficult to pool funds from their awards for equipment to be shared. Also, the rising costs of equipment have led agencies to increase their requirements for matching funds from universities (see further discussion in regulatory section below).

A Major Barrier

The mismatch between the size of individual research grants and the costs of much research equipment would be eased significantly by permitting equipment to be purchased in the initial grant-year with payment spread over the subsequent two to four years as a direct charge. The lack of such a systematic approach

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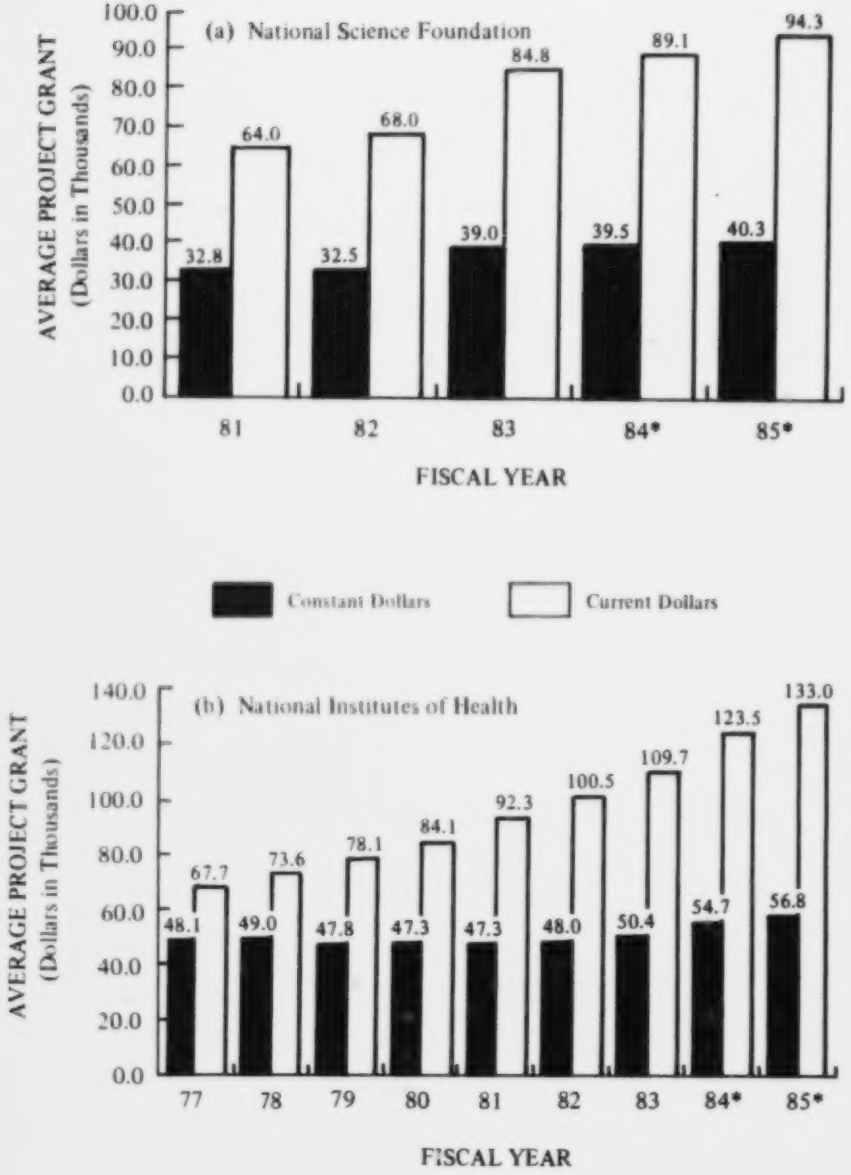
*In 1975, NIH received 12,160 grant applications; 46 percent were actually funded. In 1983, applications totaled 19,154, of which only 33 percent were funded.[15]

FIGURE 5
Average Project Grant Size



SOURCE: National Science Foundation, National Institutes of Health.
NOTE: Figures for 1984 and 1985 are estimates.*

to acquiring equipment is a major barrier to acquisition. Our conversations with chief business officers of universities revealed that most would be willing to finance or arrange for financing of research equipment if repayment, including interest, could be charged directly to grants over several years.

The indirect cost mechanism is not satisfactory to encourage equipment acquisition, because indirect costs are seldom fully recovered. Additionally, rising indirect cost rates are being attacked by the government, the Congress, and university faculty members. Increased indirect cost rates, even for equipment purchases, receive little understanding or support.

This dilemma leaves many investigators searching for ways to acquire equipment directly that entail "reasonable" financing costs. Some such mechanisms are described in Chapter 4.

Experiments with Grants

A full critique of the research-project system is beyond the scope of this report. We note, however, that the flaws in the system affect not only equipment. The administrative burden was cited above. More broadly, the emphasis on discrete tasks of relatively short duration restricts the flexibility of universities and their scientists in handling funds and pursuing research in terms of long-range, coherent programs. Federal agencies are struggling with such problems. NIH is experimenting with grants of five years or more.[15] Such grants were common at one time, but maximum award periods gradually shrank to the now-common three years during the 1970s. One of the new NIH experimental programs, the Outstanding Investigator Grant of the National Cancer Institute, is a seven-year award that will permit funds to be carried over from one year to the next.

Research Programs

Research programs funded by federal agencies involve broad, coherent areas of investigation and more than one investigator. Annual support generally exceeds $200,000. One example of a research program is a Department of Energy (DOE) grant to a university for research by a group of investigators in high-energy particle physics. Although research programs are larger than individual projects, the strengths and weaknesses of the two mechanisms are similar.

Research Centers

Federal agencies also support research centers--academic organizations that work in broad fields of research of interest to the university and the sponsoring agency. Examples include the NIH Categorical Disease Centers and the NSF Materials Research Laboratories. Research centers receive block (core) funding, as contrasted with individual project funding. Management of the center and coordination of specific research projects into a coherent program are delegated to the university. Proposals for specific research projects must be approved there, but may or may not be reviewed and approved individually by the sponsoring agency.

Our study team visited four of the 14 Materials Research Laboratories (MRLs) supported by NSF. The MRLs receive five-year block grants that support multi-investigator research on materials as well as central facilities with equipment costing in the range of $100,000 to $1 million. Block funding unquestionably eases equipment problems; the scientists we spoke with considered themselves relatively well equipped in relation to colleagues at many other universities.

A thorough study of materials research conducted at MRLs and at other universities with project-grant support was completed in 1978.[16] The results showed in part that the MRL core-grant mechanism was more efficient than project-grant funding in terms of time and money expended by NSF and the university in administering grants. The MRLs also were found to be scientifically effective. In terms of both efficiency and quality of research, however, core funding was not found to be clearly superior to other funding mechanisms examined. The results did suggest that different funding mechanisms lead to different ways of doing research and produce different kinds of science.[14]

NSF currently is starting a major new program of block-funded, multidisciplinary engineering research centers at universities.[17] The invitation to submit proposals drew 142 responses involving 3,000 investigators at 107 universities. One of the attractions of the program is the opportunity to obtain state-of-the-art equipment. Eight universities have been selected to start six of the centers in 1985. The six will receive $94.5 million from NSF over the next five years and are expected to attract additional funds from industry. As many as 20 of the centers may be established eventually. NSF plans also to spend $200 million over the next five years to set up supercomputer research centers at the University of California at San Diego, the University of Illinois at Urbana-Champaign, Cornell University, and the John Von Neumann Center near Princeton.[18]

Large Facilities

Federal agencies support a number of national and regional facilities based on equipment deemed too costly to be dedicated to use at one university. These large facilities, like research centers, receive block funding. They are designed to give academic scientists, on a national or regional basis, access to instruments that would not otherwise be available to them. Examples include the Stanford Synchrotron Radiation Laboratory (SSRL) supported by DOE and the regional instrumentation centers supported by NSF.

Large facilities serving many users predictably face problems peculiar to that mode of operation (see discussion of National and Regional Facilities in Chapter 3). For example, instruments commited to a broad range of users cannot also be modified to meet highly specialized needs. Large centers can provide only limited access to the instrumentation, causing delays in research. Costs of travel and lodging are rising sharply, and centers are sometimes geographically isolated from universities. At national facilities, with equipment costing millions of dollars, the only realistic option is to find ways to minimize the problems. The cost of equipment at regional facilities, on the other hand, may not absolutely bar providing it for one university, providing that the equipment is utilized fully and effectively. Resolution of such issues requires an evaluation of costs versus scientific effectiveness, such as the study of the NSF Materials Research Laboratories cited above.

General Research Support

Federal agencies provide general research support to universities to strengthen their research capabilities or for work in a specified subject area. The recipient has considerable discretion in the use of the funds. Such support is provided today only by the U.S. Department of Agriculture (USDA), through funding of Agricultural Experiment Stations under the Hatch Act and related programs, and by NIH in its Biomedical Research Support Grants. The experiment stations are attached to land-grant universities and have a relatively free hand in deciding the specific research to be undertaken so long as it is agricultural research.

The NIH Biomedical Research Support Grant (BRSG) provides institutional support based on NIH-funded research at the university. The grant is thus indirectly subject to scientific and technical review. The funding ceiling for the BRSG program is set by statute at 15 percent of total NIH appropriations for research grants. The percentage actually awarded declined from an average of almost 8 percent in the late 1960s to 1.5 percent in fiscal year 1984. BRSG awards totaled $47.4 million in 1984 and were distributed among 546 institutions.

We found that BRSG awards are highly regarded in academe because of the local discretion permitted in the use of the funds. Research equipment benefits markedly from these awards. A recent assessment shows that 25 percent of the BRSG funds spent at nine universities in 1979-1980 contributed to the purchase or maintenance of central research facilities including equipment.[19] In fiscal year 1982, BRSG awards totaling about $44 million were distributed among 516 institutions; of the total, $6.4 million, or 14.5 percent, was spent by universities on shared equipment or instruments.

NSF had a similar program from 1961 to 1974. The Institutional Grants for Science were based on all federal support for scientific research received by a university except support from the Public Health Service (mainly NIH). Obligations for these grants peaked at $15.2 million in 1967. During the 14-year life of the program, more than 50 percent of the funds awarded was used to buy instrumentation.*[20]

Special Equipment Programs

Four federal agencies in recent years have been supporting special programs that provide academic research equipment separately from the normal research funding mechanisms. The Department of Defense (DOD) has a five-year program scheduled to run through 1987; DOE has a five-year program projected to run through 1988. NIH and NSF have programs with no fixed expiration dates. The four agencies' programs are designed to respond to competitive proposals. They vary, however, in characteristics and requirements; detailed descriptions are given in Appendix C.

The magnitude of the universities' equipment problem is suggested by experience with the DOD program, which is funded at $30 million per year. For the first year of the program, fiscal year 1983, the agency received 2,500 proposals for instrumentation valued at a total of $645 million. Two hundred proposals were funded. In Phase 2 (fiscal year 1984-1985) DOD received 1,870 proposals, totaling $370.1 million, and made 452 awards to 147 institutions.

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*In the same period, NSF had two other general support programs--the University Science Development Program and the Departmental Science Development Program. Both were designed to expand capacity; they were eliminated in the early 1970s when that task was judged to be completed.[14]

An important characteristic of these special equipment programs is that generally they do not pay full costs (see Appendix C). Renovation of facilities, operation and maintenance, and similar necessities are not covered. Matching funds may be required but sometimes are only encouraged. Matching contributions often cannot include the costs of operation, maintenance, and other elements of full cost. All of the universities we visited report that these excluded costs and matching requirements are serious practical concerns in decisions to compete for funding from the special equipment programs.

Despite the differences in the programs, the agencies' general approach can be illustrated by the DOE design. A level of matching funds is not specified, but matching is a factor in evaluating the applications. DOE will not pay for renovation and installation, operation and maintenance, service contracts, and technical support. The matching contribution, however, can include the costs of shipping, installation, and renovation and modification of the space for the instrument. (In fiscal year 1984, the match also could include the costs of operation and maintenance, and we are concerned by the removal of this provision in view of the heavy costs thus excluded from matching.) The university must estimate the usable life of the instrument and demonstrate plans for ensuring its continued availabiliy during the first five years.

Operations and Maintenance

Operations and maintenance are funding problems not only in special equipment programs. These functions together, over the service of life of equipment, may cost more than the purchase price. Still, funding agencies often do not cover the costs of maintenance and professional support staff for research equipment. This situation has started to change, however. The Chemistry Division at NSF, for example, now requires a university to indicate in research proposals how it will maintain equipment. We welcome this development as long as agencies recognize their obligation to meet these costs as part of their support for research.

When funding agencies' budgets are trimmed, operating and maintenance funds are vulnerable. Astronomers at one university we visited, for example, were given a computer developed several years ago for image scanning. They have been funded by NSF to adapt it to a facility for automated plate scanning but anticipate trouble supporting it once it is operational, as NSF will not allow user charges to the astronomy community. We learned of a similar circumstance at another university involving a gas-phase sequencer funded by an NIH grant; the proposal had requested funds for a supporting technician, but these were cut by the agency.

Excess Property

The federal excess property program makes research (and other) equipment available to universities under certain conditions. Equipment made available through the excess property program is usually useful to researchers, but is not state of the art. It includes items such as machine tools, vehicles, trailers, motors, pumps, cameras, and machine parts. These items reduce the cost of performing research but add to the administrative burden because of extensive recordkeeping requirements.[21,22]

The excess property program was modified in 1976 by Public Law 94-519, implemented by regulations on October 20, 1977.[23] Congress purposely placed restraints on the program because of abuses by many local governments and other grantees. Public Law 94-519 also liberalized the surplus property programs so that surplus property became available to a wider group of nonprofit organizations. It is important here to distinguish between excess property and surplus property. Excess property is that which is no longer needed by the agency that owns it and therefore is offered by the General Services Administration to all other federal agencies. If no agency needs it, it becomes surplus property. Now that a larger audience has access to surplus property, some universities are finding items heretofore easily obtained at state agencies for surplus property to be first reserved for other nonprofit entities.

The 1977 regulations that implement PL 94-519 appeared to be a deliberate attempt to discourage agencies from giving excess property to grantees. The discouragement took the form of imposing on the agencies intricate and unreasonable requirements for recordkeeping, reporting, and other paperwork. One example is the requirement that "all nonfederal screeners shall be subject to certification by federal authority." That is, a university researcher must state qualifications to screen excess property. Additionally, the researcher must submit a passport-style photograph with signature.

Investigators inquire from time to time about the possibility of reestablishing the excess property program as it was before 1976, when excess property could be obtained with ease.

DOE is upgrading and enhancing its excess property program to provide used instrumentation from DOE-supported national laboratories to universities for use in energy-related research and educational programs. Current DOE funding is not a prerequisite. Lists of excess equipment are available at designated DOE sites and are published monthly by the Government Printing Office.

Generally smaller instruments, such as microscopes, oscilloscopes, spectrometers, and chromatographs are made available on a first-come basis. Universities with DOE research grants may also gain access to the list of eligible equipment through DOE-RECON, an interactive, computer-based system managed by the agency's Office of Scientific and Technical Information at Oak Ridge, Tennessee. For other investigators, the data base is being put on a microcomputer for access by terminal and modem via telephone in a pilot program scheduled for operation in 1985.

Federally Subsidized Loans

Four programs are authorized under the Higher Education Act of 1965 (PL 89-329) to provide loans or interest subsidy grants on loans from nonfederal sources. They would reduce borrowing costs to universities for the construction, reconstruction, or renovation of academic facilities, which could include research equipment. The loan programs are unfunded, however, and the interest subsidy program is funded only to pay interest subsidies on prior loans. No equipment-specific federal loan program is currently authorized.

We analyzed the potential usefulness of a loan subsidy program by developing hypothetical models and comparing costs (see Appendix D). We looked at three alternatives: loan guarantee, loan guarantee with interest subsidy, and direct loan with low interest. The loan guarantee appears to have no particular advantage. Of the two remaining alternatives, the direct, low-interest loan would be cheapest, given favorable rates of interest. We have not assessed the potential effects of the loan programs hypothesized in Appendix D on the overall distribution of public funds for academic research and research equipment. One question that would warrant attention is whether such programs would encourage expansion of the nation's total research capacity, as opposed to upgrading or replacing equipment already in place in research institutions. A broader issue would be the effectiveness of loan programs, in terms of both economic and scientific efficiency, relative to other federal options for funding academic research equipment.

FEDERAL REGULATORY ISSUES

Federal regulations play an important role in the acquisition, management, and use of equipment for federally supported research at universities. Sometimes they create barriers to acquisition, complicate management, and may discourage appropriate use of research equipment. Because regulations that deal with research equipment are designed to control, rather than facilitate, its acquisition, management, and use, they hamper innovative approaches to more effective use of existing resources. More precisely, federal regulations are usually framed in language that permits both universities and the government to accommodate individual circumstances. It is the application or interpretation of the rules that appears in most instances to create barriers.

The most critical barriers are barriers to cost recovery, since these are the ones most likely to influence the acquisition decision. Our approach to identifying barriers began with a regulatory inventory in each area of acquisition, management, and use. It also entailed a careful assessment of whether the actual rule or its various interpretations were creating barriers.

Regulatory Framework

For grants, the principal governmentwide rules controlling the acquisition, management, and use of federally supported research equipment are contained in two Office of Management and Budget (OMB) circulars: OMB Circular A-21 (Principles for Determining Costs Applicable to Grants, Contracts, and Other Agreements with Educational Institutions) and OMB Circular A-110 (Uniform Administrative Requirements, Grants, and Agreements with Institutions of Higher Education).

These circulars are often supplemented by agency issuances, but those issuances are not supposed to be more restrictive than the OMB circulars. OMB Circular A-21 states, "Agencies are not expected to place additional restrictions on individual items of cost." OMB Circular A-110 says, "the standards promulgated by this Circular are applicable to all Federal agencies...exceptions from the requirements of the Circular will be permitted only in unusual cases. Agencies may apply more restrictive requirements to a class of recipients when approved by the Office of Management and Budget." Agency supplements, however, are not always consistent with OMB guidance. Between the foregoing principles and their application in individual circumstances, a wide gap often exists.

For contracts, the Federal Acquisition Regulation (FAR) and OMB Circular A-21 are the principal governmentwide rules controlling the acquisition, management, and use of federally supported research equipment. The basic FAR is further supplemented by agency issuances. The Department of Energy, for example, supplements the FAR by its Department of Energy Acquisition Regulations (DEAR). The Department of Defense does the same with the Defense Federal Acquisition Regulation Supplement (DFARS), and so on. All of this follows principally from the basic grants statute, the Federal Grant and Cooperative Agreement Act (PL 95-224) and three procurement statutes.[24] Only specific parts of each of these circulars and/or grant or procurement rules are concerned with the acquisition, management, and use of research instrumentation.

Table 1 shows the principal contract rules that affect research equipment. Table 2 shows the principal grant rules that affect research equipment. An inventory was necessary because whenever instances of regulatory barriers were raised, it was essential to identify which federal regulations created them.

Several terms warrant explanation. First, the terms equipment, instrumentation, and personal property are synonymous as used here. Second, equipment or property is defined in OMB Circular A-21 [Section J.13.a(1)] as a tangible item having a useful life of more than two years and an acquisition cost of $500 or more. Third, the FAR governs procurement by all federal agencies and applies to all contractors.

Barriers to Acquisition and Optimum Management and Use

The most troublesome barriers to acquisition and optimum management and use of equipment, as mentioned earlier, are those dealing with cost recovery. A notable example is the lack of a regular mechanism that permits the cost of equipment to be recovered directly from research grants by spreading the cost over several grant-years (see previous discussion under Funding Mechanisms). Other barriers we identified include uncertainty of title to equipment, requirements for matching funds, restrictions on combining funds, and the extensive reporting and approval requirements for obtaining equipment. Equipment screening and inventory requirements were cited as expensive and unnecessary paperwork burdens.

The Uncertainty Barrier

The uneven application and inconsistent interpretation of the rules occur at several points in the system owing to the practices

TABLE 1 Regulations Affecting Cost-Reimbursement Contracts That Include Acquisition of Research Equipment

Agency	Acquisition and Title	Management and Use	Records and Reports	Cost Recovery
Principal Regulations				
DOD/GSA/NASA FAR	35.014 45.302-1 (Facilities only) 52.245-5(c)(4) Alternate 1 52.244-2	52.245-5 (e)-(1) (Government Property only)	52.245-5(c)(4) Alternate 1	35.014(b)(4) 52.245-5(c)(4) Alternate 1
OMB Circular A-21 (FAR 31.303)	3.13.b.(2) and 3.38 C.4.b.		3.9.e.	3.9 and 3.17.e

Agency	Acquisition	Management and Use	Records and Reports	Cost Recovery
Supplemental Agency Regulations				
DHHS: HHSAR				
DOD: DFARS	235.014			
	Page 252.235-14 (2 clauses)	Page 252.235-15		
	270.601 (ADPE)	270.605 (ADPE)		
NSF: NSFAR				
DOE: DEAR	917.7108	917.7113 (SRC) Article B-IX		917.7108-1(d)
	917.7113 (SRC) Article B-IX	945.104-70	945.102-70	
	935.014	945.5 952.245-5	945.505-14 952.245-5	
USDA: AGAR				
NASA: NASA FS	1835.014 1845.502-72 1845.70	1845.72	1845.505-670	

NOTE: FAR, Federal Acquisition Regulation; HHSAR, Health and Human Services Acquisition Regulation; DFARS, Defense Federal Acquisition Regulation System; NSFAR, National Science Foundation Acquisition Regulation; DEAR, Department of Energy Acquisition Regulation; AGAR, Agriculture Acquisition Regulation; NASA FS, National Aeronautics and Space Administration Acquisition Regulation.

TABLE 2 Principal Regulations Affecting Grants That Include Acquisition of Research Equipment

Agency	Acquisition and Title	Governmentwide Management and Use	Records and Reports	Cost Recovery
OMB				
Circular A-21	3.13.b.(2), 3.38 and C.4.b.		3.9.e	3.9., 3.18.e
Circular A-110, Attachment N	para. 5	paras. 5 and 6	paras. 5 and 6	
Circular A-110, Attachment O	paras. 3.b. and 3.c.			
Agency Provisions To Implement OMB Circulars				
HHS: PHS Grants Policy Statement	Pages 32 and 35 (Addendum) 45, 48-49, 51, 81	Pages 48-50, 81		Pages 32, 33
DOD: AFOSR[a] Brochure	Page 14	Page 15	Page 15	
NSF: Grant Policy Manual	GPM 512.3, 515 524, 772.1	GPM 204.2, 332, 773		
DOE/OER:[b] Proposed 10 CFR[c] Part 605	sec. 605.17(a)(1)			
USDA: 7 CFR Part 3015	sec. 3015.164, sec. 3015.196	sec. 3015.165-.170		
NASA: Grant and Cooperative Agreement Handbook	para. 408	para. 408, para. 508(d), para. 509	sec. 1509	

[a] Air Force Office of Scientific Research.
[b] Office of Energy Research.
[c] Office of Code of Federal Regulations.

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of agency program officers, contract/grant officers, and auditors. Although federal regulations, as written, almost always give the government and the universities sufficient latitude to accommodate individual circumstances, well-meaning government officials interpret the regulations in ways that vary from region to region and from agency to agency. These inconsistent interpretations cause many university officials to behave cautiously, especially in generating innovative debt instruments to secure costly, short-lived, state-of-the-art research equipment. They already have tough decisions to make on accumulating debt, without having to worry that, sometime in the future, disallowances may be sustained on the basis of circumstances then existing, rather than on circumstances at the time of acquisition. Uncertainty is a critical barrier.

Cost-Recovery Barriers

In addition to the inability to recover the cost of equipment directly over several years, we identified three regulatory barriers to acquisition, and all deal with restrictions on cost recovery. They are (1) the inability to recover interest on borrowed funds, (2) the unrealistically low allowance for equipment use, and (3) the prohibition against setting an optimal price (user charge) for equipment use and replacement.

Recovery of Interest The first barrier leaves recovery of the full cost of a piece of equipment uncertain. OMB Circular A-21 was amended in August 1982 to give federal agencies the discretion to approve interest on equipment financing as an allowable indirect cost. This discretion was restricted to interest on externally borrowed funds. Interest on a university's own funds used to finance equipment is not an allowable cost. There are instances where agencies have approved recovery of interest on external borrowing, but we found several cases in which approval was denied. A decision not to allow recovery of interest costs is often sufficient disincentive to cause academic decision makers not to use debt financing to acquire research instruments from either internal or external sources.

Use Allowance/Depreciation The second barrier is the unrealistically low allowance permitted for federal reimbursement of the use of equipment purchased with nonfederal funds. This allowance is called a "use allowance" and is computed at an annual rate not to exceed 6 2/3 percent of acquisition cost. The full cost is thus recoverable in no less than 15 years, but the realistic life of state-of-the-art research equipment is three to five years. Recognizing the disadvantage of the use allowance method, some universities wish to convert to a depreciation method of cost recovery. OMB Circular A-21 permits such conversion and permits full recovery of the cost of an asset, notwithstanding a university's previous decision to rely on the use allowance method. The Department of Health and Human Services (DHHS) does not object to the conversion, but will only permit recovery of equipment costs as if the equipment were being depreciated during the years it was actually covered by the use allowance. This interpretation has the effect of denying full recovery of the cost of equipment. As noted at the outset, DHHS audits 95 percent of all colleges and universities.

Government rules permit depreciation or use allowance only on equipment not purchased by the federal government. However, 63 percent of all academic research instruments purchased in 1983 was acquired with federal funds. These items cannot be depreciated nor may a use charge be assigned to recover the purchase price from federal awards.

A second problem in switching from use allowance to depreciation is that depreciation will usually result in more rapid cost recovery, which in turn raises indirect cost rates. Increases in indirect cost rates are not acceptable to some investigators for any reason.

User Charges The third cost-recovery barrier to acquisition is the stricture on differential pricing of centralized service facilities and provision for reasonable replacement cost of the equipment involved if it is federally financed. These specialized service centers contain instruments like central computer equipment or electron microscopes. OMB Circular A-21 (Section J.38) says the cost of using these facilities shall be charged directly to users based on actual use and a schedule of rates that does not discriminate between federal and nonfederal activities including use by the university for internal purposes. But the circular also says, "where it is in the best interest of the Government and the institution to establish alternative costing arrangements such arrangements may be worked out with the cognizant Federal agency."

The cost of using large centralized and specialized pieces of equipment often is set too high for optimal use by all investigators. Where individual project grants are not funded well enough to permit paying full costs, differential pricing would encourage greater use of a facility but would necessarily mean charging some users more than others. While the cognizant agency has the authority to establish alternative arrangements, we found no instances of differential pricing. It is unlikely that such arrangements can actually be established, unless the university offers its own money to subsidize the facility. Even if one were able to recover full operating costs, there is no provision for setting a fee for eventually replacing or modernizing the equipment. The government argues that an allowance for replacement is tantamount to paying for an instrument twice and, further, that a set-aside for replacement is without benefit of scientific review. Again, these uncertainties and inconsistencies mitigate against acquisition and effective use of research equipment.

Matching Requirements

Federal agencies that award funds for research equipment may expect or require universities to contribute funds toward the cost of such equipment. Investigators argue that the required contributions, or matching funds, are usually too great and point out that the university's payment of costs such as installation, operation, and maintenance is not as a rule considered part of the match. The governmentwide rules that apply to matching are contained in OMB Circular A-110, Attachment E. The rules in Circular A-110 are not in themselves burdensome, but each federal agency uses different criteria to decide what it considers an acceptable contribution. It is the unspecified match, or the uncertainty of what is acceptable, that creates a perception of inconsistency in federal regulations on matching.

Actually, the amount and character of a university's matching contribution are determined by the individual agency and usually are consistent with its intent and program purpose. Program managers are given broad latitude in setting matching requirements. They argue that this latitude is needed to assure the best possible use of federal money.

Matching, as the term is used here, differs from cost sharing, which is the requirement that the university contribute to the total cost of a research project, which may or may not involve equipment.

Ownership of Equipment

Some federal agencies do not vest title to equipment in the university receiving the support. In this instance, the problem is found in both the letter and the interpretation of the regulations. Without assurance of title, investigators hesitate to combine university funds with federal funds to acquire an instrument--they may find that it belongs entirely to the federal government.

To cite an example, the Public Health Service (PHS) vests title to equipment purchased under its grants without obligation on the part of the university.* This practice is consistent with the intent of the Federal Grant and Cooperative Agreement Act, which states,

> The authority to make contracts, grants, and cooperative agreements for the conduct of basic or applied scientific research at nonprofit institutions of higher education, or at nonprofit organizations whose primary purpose is the conduct of scientific research shall include discretionary authority, when it is deemed by the head of the executive agency to be in furtherance of the objectives of the agency, to vest in such institutions or organizations, without further obligation to the Government, or on such other terms and conditions as deemed appropriate, title to equipment or other tangible personal property purchased with such funds.[25]

The Department of Energy, on the other hand, does not automatically vest title to equipment purchased under its contracts.† Such inconsistent practices among agencies inhibit efficient acquisition, management, and use of equipment.

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*Consistent with OMB Circular A-110, the PHS reserves the right to require transfer of title to equipment from one grantee to another or to the federal government even though title was vested in the university upon acquisition. This is known as "conditional" title, but has created no reported problems. This option must be exercised within 120 days after the end of PHS support for the project. Other agencies that transfer title upon acquisition also vest conditional title (Code of Federal Regulations 45, sec.74.136).

†The Department of Energy does not now award many research grants but relies rather on research contracts. Departmental policy urges that equipment title be transferred to universities upon acquisition, but investigators say that DOE ignores its own policy. Recently the department announced that the Office of Energy Research would be issuing a significant number of special research grants. An announcement in the Federal Register to facilitate those grants appeared on April 15, 1985 (50 FR 14856); we understand that DOE operations offices will be encouraged to vest title upon acquisition and may vest title to equipment previously purchased on contracts.

Problems arise when investigators attempt to acquire an instrument by combining funds from their own grants or contracts from the same or different agencies, for example, or when two investigators want to purchase an instrument jointly with funds from the same or different agencies. Where title to the instrument vests in the government, rather than the university, it is easy to understand the reluctance of a university official to arrange financing. The government may prove to be unable or unwilling to continue support for the project at an appropriate level, leaving the university to pay for a piece of equipment that belongs to the government.

Inconsistencies in Federal Contract Rules

The Federal Acquisition Regulation was described earlier as the basic governmentwide set of rules governing all federal procurement including the acquisition, management, and use of federally supported research equipment under contracts. The FAR is of recent origin (April 1984) and was developed to resolve the inconsistencies of the old agency-by-agency procurement regulations. The intent was admirable, but the agencies were permitted to develop supplements that implement the FAR, and these in some instances created new inconsistencies. In several cases, there are inconsistencies among the agency supplements. In other instances, the FAR itself is internally inconsistent.

For universities the FAR presents two problems.[26] First, definitions of equipment and facilities do not distinguish between industrial facilities, plant equipment, and special tooling, on the one hand, and research facilities and equipment on the other. Because the definitions of equipment are not clear, universities have long been subjected to unrealistic requirements, such as screening requests for state-of-the-art equipment through the Defense Industrial Plant Equipment Center (DIPEC) before the equipment can be purchased with DOD funds.* Such screening is required because research equipment is included in the definition of the term "industrial plant facilities."

The universities we visited felt that the descriptions of equipment in the DIPEC inventory do not suffice to permit a federal property officer to determine whether an instrument in the inventory is an adequate substitute for the one requested. We encountered no one who could identify scientific or technical equipment acquired via DIPEC screening. Hence the required time-consuming screening is wasteful for both the universities and the government and serves no useful purpose for research equipment.

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*The National Aeronautics and Space Administration has a similar screening system, the Equipment Visibility System (EVS).

The DOD definitions of what constitutes equipment are so oriented toward manufacturing and production as to mean little to research contracts with universities.

The second difficulty is the inconsistency of the FAR contract clauses governing vesting of title, which are not in accordance with PL 95-224. This law contains the statutory authority for vesting title to equipment. The policies on title to equipment acquired by universities provide that the "contractor shall automatically acquire and retain title to any item of equipment costing less than $5,000" and "if purchased equipment costs $5,000 or more," the parties may agree that title vests in the contractor on acquisition, or they may select among several other options. The contract clause that implements this policy provides that title ordinarily vests in the government, rather than with the contractor. It also provides, however, that title to equipment costing less than $1,000 may vest in the contractor on acquisition but only if, before each acquisition, the contractor has obtained agency approval.

Capital Equipment Thresholds and Inventory Requirements

OMB Circulars A-21 and A-110 specify cost thresholds for capitalizing equipment that are inconsistent and unrealistically low. The threshold is $500 in Circular A-21 and $300 in Circular A-110.

OMB Circular A-21 defines equipment as "tangible personal property having a useful life of more than two years, and an acquisition cost of $500 or more per unit." OMB Circular A-110 defines equipment as "tangible personal property having a useful life of more than one year, and an acquisition cost of $300 or more per unit."

OMB Circular A-21 addresses capitalization levels for purposes of cost recovery and allowability; OMB Circular A-110 addresses the management of equipment. Circular A-21 also requires approval in advance of purchase of special-purpose equipment costing $1,000 or more.

If colleges and universities wish to be reimbursed for depreciation or use allowance on equipment, they must maintain property records and conduct a physical inventory at least once every two years. The university must ensure that the equipment is used and needed. Colleges and universities that seek such reimbursement keep property records and conduct inventories, but those inventories are for purposes of cost reimbursement, rather than for equipment management.

The difference in the two circulars' capitalization thresholds—$500 versus $300—creates difficulty in equipment management. The Circular A-110 definition requires keeping track of significantly more items than does the Circular A-21 definition. Management of the inventory would go more smoothly if both thresholds were raised and made uniform.

Two universities we visited estimate that a threshold of $1,000 would halve the number of items in the typical university inventory of capital equipment while retaining 80 percent of the combined value of the equipment. At a third university, 80 percent of the items in the inventory of equipment bought in 1983 accounted for less than 20 percent of the dollar value of the inventory.

Circular A-110 requires that universities "assure the avoidance of purchasing unnecessary or duplicative items." This requirement is interpreted to mean that universities must screen their equipment inventories prior to purchase. Faculty investigators generally are willing to share to cut costs, but we were told that the $300 threshold requires considerable screening for items that are not economically suited to sharing. Some universities have negotiated higher screening thresholds with their auditors. The screening level at one university we visited, for example, is $10,000. It accounts for 3.2 percent of the items in the inventory of equipment bought in 1983 and for 50 percent of the dollar value.

Prior Approval Systems

Purchases of equipment costing more than $1,000 and not otherwise approved for acquisition with NIH and NSF project-grant funds ordinarily can be approved by the university under the NIH Institutional Prior Approval System (IPAS) and the NSF Organizational Prior Approval System (OPAS). These systems eliminate some of the postaward restrictions attached to the project grant, such as the requirement for prior approval by the agency to incur certain costs or to shift funds among budget categories. IPAS and OPAS emphasize the grantee's flexibility to allocate resources to achieve optimum research outputs and are valued highly by investigators and administrators. They reduce turnaround time on requests from six or more weeks to a few days, thereby permitting the university to take advantage of timely price discounts or other special arrangements.

Under IPAS and OPAS, the universities are charged with adhering to both the agencies' grant regulations as well as university standards. Both individual transactions and the procedures themselves are subject to review by the agency and the auditor. The universities must retain documentation of their IPAS/OPAS transactions.

The NSF OPAS contains a provision that permits the university to incur cost up to 90 days before a grant is awarded. This provision can reduce lags in start-up caused by delays in delivery of equipment. It also gives the university ample opportunity to obtain maximum benefit from negotiations, including taking advantage of tax incentives to industry for donations and bargain sales of equipment. The OPAS makes it easier to combine funds from NSF grants when the grants are scientifically related. Additionally, the university is authorized to rebudget grant funds for renovations costing less than $10,000.

The Public Health Service is currently in the second phase of an experiment with the IPAS. This experiment extends additional approval authority to the university. It includes the ability to make decisions on the purchase of general-purpose equipment to be used for scientific applications. General-purpose equipment includes items like cargo vehicles, computing equipment, cameras, and refrigerators.

The Office of Naval Research (ONR) operates a system that, among other functions, moves the locus of government decision making closer to the campus. ONR resident representatives on or near campuses around the country can approve purchases locally, which considerably expedites the acquisition process. The resident representative is usually authorized to approve purchases on behalf of agencies other than DOD. This system provides certain benefits comparable to those of IPAS and OPAS, although it does not constitute delegation of prior approval authority to the universities.

RECOMMENDATIONS

Traditional federal funding mechanisms, although they account for well over half of expenditures on academic research equipment, do not on balance comprise adequate means of regularly replacing obsolete or worn-out equipment. Current special equipment programs, operated outside the traditional funding channels, are extremely useful. Still, they were designed largely to respond to an emergency and, at present levels, obviously are not a long-term solution to the equipment problem.

Federal regulatory practices are an element of the problem. Few federal regulations directly prevent the acquisition of research equipment by universities or hamper its operation, maintenance, and replacement; however, the interpretation of regulations does impede acquisition and especially complicates management and replacement and modernization of research equipment.

We recommend...

1. **That the heads of federal agencies supporting university research issue policy statements aimed at removing barriers to the efficient acquisition, management, and use of academic research equipment.** Few federal regulations, as written, contribute directly to the equipment problem. Inconsistent interpretation of regulations by federal officials, however, complicates the purchase, management, and replacement of research equipment and leads to unnecessarily conservative management practices at universities. Desirable actions are summarized in the recommendations below.

2. **That federal agencies more adequately recognize and provide for the full costs of equipment, including operation and maintenance, space renovation, service contracts, and technical support by...**

...providing these costs in project grants and contracts or ensuring that recipients have adequately provided them.

...accepting universities' payment of costs such as installation, operation, and maintenance as matching funds on programs that require matching contributions by universities.

3. **That federal agencies adopt procedures that facilitate spreading the cost of more expensive equipment charged directly to research-project awards over several award-years and allow the cost and use of equipment to be shared across award and agency lines.** Individual research-project grants and contracts normally can accommodate equipment of only modest cost. Investigators, moreover, have difficulty combining funds from awards from the same or different agencies to buy equipment.

4. **That federal auditors permit universities to recover the full cost of nonfederally funded equipment from federal awards when they convert from use allowance to depreciation.** Office of Management and Budget (OMB) Circular A-21 permits such conversion as well as recovery of full cost. Auditors of the Department of Health and Human Services, however, permit recovery only as if the equipment were being depreciated during the time it was in fact covered by the use allowance. This practice, in effect, denies recovery of full cost.

5. **That the Office of Management and Budget make interest on equipment funds borrowed externally by universities unequivocally an allowable cost by removing from OMB Circular A-21 the requirement that agencies must approve such charges.** Interest on externally borrowed funds has been a permissible cost since 1982 at the discretion of the funding agency, but agencies have shown significant reluctance to permit it. The perception of inability

to recover interest costs may lead university officials to decide against seeking debt financing for equipment.

6. **That all federal agencies vest title to research equipment in universities uniformly upon acquisition, whether under grants or contracts.** Federal regulations on title to equipment vary among agencies, and such variability inhibits efficient acquisition, management, and use of equipment. Without assurance of title, for example, investigators hesitate to combine university funds with federal funds to acquire an instrument not affordable by a single sponsor.

7. **That the Office of Management and Budget make federal regulations and practices governing management of equipment less cumbersome by...**

...setting at $10,000 the minimum level at which universities must screen their inventories before buying new equipment and, above that minimum, permitting universities and agencies to negotiate different screening levels for different circumstances.

...raising the capitalization level for research equipment to $1000 in OMB Circulars A-21 (now at $500) and A-110 (now at $300) and giving universities the option of capitalizing at different levels.

8. **That the Department of Defense eliminate its requirement that the inventory of the Defense Industrial Plant Equipment Center (DIPEC) be screened for the availability of specialized scientific equipment requested by universities before new equipment is purchased.** The descriptions of equipment in the DIPEC inventory do not permit a federal property officer to determine whether a scientific instrument in the inventory is an adequate substitute for the one requested. Hence, the requirement for screening is wasteful for both universities and the government.

9. **That other federal agencies adopt the NIH and NSF prior approval systems.** Purchases of equipment with federal funds ordinarily must be approved in advance by the sponsoring agency. Purchases can be approved by the university, however, under the NIH Institutional Prior Approval System and the NSF Organizational Prior Approval System. These systems markedly improve speed and flexibility in acquiring equipment.

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26. Federal Acquisition Regulation, Part 45 and Part 52.

2

The State Role in the Acquisition and Management of Research Equipment

INTRODUCTION

State governments play significant but often conflicting roles in regard to academic research equipment. On the one hand, they provide important funding for such equipment both directly and, by means of tax benefits, indirectly. On the other hand, states often constrain the acquisition and management of research equipment through regulatory controls and restrictions on public universities' general financial flexibility.

Data on state funding of research equipment in universities are sparse, and trend data do not exist. The National Science Foundation's (NSF's) National Survey of Academic Research Instruments has developed figures on the amount, condition, and cost of existing research equipment. The figures show that states directly funded 5 percent of the aggregate acquisition cost of major research instrumentation systems in use in academe in 1982-1983 (Table 3). This percentage is probably an underrepresentation of state support for many public institutions, since the self-reported university contribution may include general-purpose state appropriations. State funds for research equipment are rarely available to private universities; the NSF data show that private schools received only 2 percent of direct state funding for equipment covered by the survey, whereas public schools received 98 percent (Table 4).

States provide some funding for research and development at colleges and universities, and an unknown fraction of these expenditures goes for research equipment. State and local governments accounted for 15 percent of total spending on academic R&D in 1953 and 7 percent in 1983 (Figure 2, Chapter 1). The decline reflects the rise in federal funding during that period (Appendix A). In constant dollars, state funding grew about 8.9 percent annually during 1953-1967 and about 1.8 percent annually during 1967-1983. Federal funding of academic R&D, in real terms,

TABLE 3 Sources of Funds for Acquisition of Academic Research

		Federal			
	Total	Total	NSF	NIH	DOD
Total, Selected Fields	$1,178.0	$640.3	$230.8	$176.5	$103.9
	100%	54%	20%	15%	9%
Agricultural Sciences	36.1	7.8	1.7	1.3	0
	100%	21%	5%	4%	-
Biological sciences, total	381.3	198.5	35.3	149.7	2.1
	100%	52%	9%	39%	1%
Graduate schools	156.1	80.6	24.5	48.9	1.0
	100%	52%	16%	31%	1%
Medical schools	225.2	117.9	10.8	100.8	1.2
	100%	52%	5%	45%	-
Environmental sciences	92.3	45.7	16.5	0.5	6.6
	100%	50%	18%	-	7%
Physical sciences	351.9	229.1	116.1	19.5	32.3
	100%	65%	33%	6%	9%
Engineering	218.9	106.4	35.1	2.7	45.8
	100%	49%	16%	1%	21%
Computer science	46.9	21.5	10.8	0.3	9.1
	100%	46%	23%	1%	19%
Materials science	34.1	24.3	13.5	0.7	5.4
	100%	71%	40%	2%	16%
Interdisciplinary, not	16.6	7.0	1.8	1.9	2.4
elsewhere classified	100%	42%	11%	11%	15%

[a] Individuals and nonprofit organizations.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic

Equipment in Use in 1982-1983, by Field (Dollars in Millions)

Funding				Nonfederal Funding			
DOE	NASA	USDA	Other	Univ. Funds	State Govt.	Business	Other[a]
$63.1	$30.8	$5.0	$30.2	$371.5	$61.5	$43.2	$61.5
5%	3%	-	3%	32%	5%	4%	5%
0.3	0.3	2.7	1.5	17.8	6.7	1.8	2.1
1%	1%	7%	4%	49%	18%	5%	6%
3.5	0.4	1.9	5.5	131.2	18.6	6.5	26.5
1%	-	-	1%	34%	5%	2%	7%
0.7	0.4	1.7	3.5	48.2	13.0	4.3	10.0
-	-	1%	2%	31%	8%	3%	6%
2.9	0	0.2	2.1	83.0	5.5	2.3	16.4
1%	-	-	1%	37%	2%	1%	7%
8.2	5.4	0	8.5	27.5	7.2	8.4	3.5
9%	6%	-	9%	30%	8%	9%	4%
33.0	22.3	0.1	5.7	92.2	6.6	4.1	20.0
9%	6%	-	2%	26%	2%	1%	6%
14.4	2.2	0.3	5.8	78.5	13.5	13.1	7.4
7%	1%	-	3%	36%	6%	6%	3%
0.3	0	0	1.0	11.5	4.9	7.7	1.2
1%	-	-	2%	25%	10%	16%	3%
3.4	0	0	1.3	6.0	2.6	0.6	0.6
10%	-	-	4%	18%	8%	2%	2%
0	0	0	0.9	6.8	1.5	0.9	0.4
-	-	-	5%	41%	9%	6%	2%

Research Instruments and Instrumentation Needs.

TABLE 4 Acquisition of Research Instrument Systems in Use in Purchase Cost (Dollars in Millions)

		Federal			
	Total	Total	NSF	NIH	DOD
Total	$1,178	$640.3	$230.8	$176.5	$103.9
	100%	100%	100%	100%	100%
Type of University					
Private	429.9	268.3	102.8	74.7	53.1
	36%	42%	45%	42%	51%
Public	748.1	372.0	128.0	101.8	50.8
	64%	58%	55%	58%	49%
System Purchase Cost					
$10,000-$24,999	324.9	176.7	43.5	82.6	21.5
	28%	28%	19%	47%	21%
$25,000-$74,999	372.6	194.2	68.9	53.2	37.4
	32%	30%	30%	30%	36%
$75,000-$1,000,000	480.5	269.4	118.4	40.7	45.0
	41%	42%	51%	23%	43%

[a] Individuals and nonprofit organizations.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic

1982-1983 by Source of Funds, Type of University, and System

Funding			Nonfederal Funding				
DOE	NASA	USDA	Other	Univ. Funds	State Govt.	Business	Other[a]
$63.1	$30.8	$5.0	$30.2	$371.5	$61.5	$43.2	$61.5
100%	100%	100%	100%	100%	100%	100%	100%
15.2	12.8	0.3	9.4	109.9	1.3	24.7	25.7
24%	42%	6%	31%	30%	2%	57%	42%
47.9	17.9	4.8	20.8	261.7	60.1	18.5	35.9
76%	58%	94%	69%	70%	98%	43%	58%
14.2	4.9	2.8	7.3	102.7	20.1	8.6	16.8
22%	16%	56%	24%	28%	33%	20%	27%
15.1	8.6	1.8	9.3	126.2	20.3	13.9	18.0
24%	28%	36%	31%	34%	33%	32%	29%
33.8	17.3	0.4	13.6	142.6	21.0	20.7	26.7
54%	56%	8%	45%	38%	34%	48%	43%

Research Instruments and Instrumentation Needs.

grew about 1.6 percent annually during 1967-1983 but from a base more than eight times the base for state and local government.

The critical question is the degree to which state funds and tax benefits intended specifically to aid academic research are countered by constraints general to state government. State procurement laws, for example, tend to be highly conservative, and creative financing is viewed warily. States traditionally rely on negative controls to assure fiscal integrity. Such controls do not lend themselves readily to expeditious acquisition and upgrading of complex and costly research instrumentation or to alternative modes of financing. States typically do not have a regular mechanism for replacing obsolete research equipment nor do they recognize its rapid obsolescence when providing initial funding for equipment purchases. Other constraints include bars to the use of equipment by private entities and replacement policies inconsistent with the unique nature and often quite short useful life of research equipment. Finally, most states continue to treat the acquisition of research equipment, almost without regard for its cost, as an operating expense. Thus, the capital financing methods common in business, and used increasingly by private universities, remain the exception for state-funded equipment.

MODES OF STATE SUPPORT

The state and federal approaches to funding research equipment differ in part on philosophical grounds. For example, states sometimes do not consider research and graduate study among their primary responsibilities; more specifically, they consider basic research a federal responsibility. Some states, in fact, budget only for instruction in their institutions of higher education.

State support is usually institutional, with only limited consideration of specific pieces of equipment; federal support, in contrast, is mainly project oriented and independent of the overall financing of the institution. State funding is very likely to be in a form that merges support for equipment into a general operating base; a federal research grant is likely to anticipate the acquisition of specific equipment. State funding of scientific equipment usually is associated with new buildings or major new programs. Most state purchasing regulations draw no distinction between research equipment and other equipment, whether for use by universities or other state agencies. State allocations that cover equipment, moreover, usually also cover diverse and undifferentiated instructional, administrative, and maintenance needs.

Federal and state policies toward public and private universities also differ significantly. With only minor exceptions, the federal government treats public and private universities alike in the award and management of funds for research and research equipment. States, on the other hand, impose on public universities considerably more control, particularly fiscal control, than they impose on private universities. Except for controls entailed by their use of state borrowing authority, private universities are exempt from virtually all state controls on the acquisition and management of research equipment.

State support of colleges and universities is largely shaped by the state appropriations process. Typically the process supplies operating and capital funds for a budget period of one or two years. The "base budget" reflects the costs of operating and maintaining the institution at existing levels; generally it includes allocations, often quite small, for buying and maintaining equipment. The base budget may or may not reflect inflation, depending on state practice. At the end of the budget period, unexpended or uncommitted balances generally revert to the state's general fund.

Proposals for new or expanded programs, and the associated equipment, must include well-justified cost analyses and projections and must be submitted for legislative scrutiny during the appropriations process. The economic health of the state and the interests of its political leadership are critical factors in the treatment of such budgetary proposals.

States are usually under heavy pressure to pay for current operations, and very few are able to fund equipment replacement reserves. State budget officers increasingly are requiring public universities to include replacement reserves in their budget presentations. Unfunded reserves, however, set up false expectations, often exacerbated by useful-life tables that are too long relative to the actual useful life of research equipment.

The regulations associated with state support (Appendix E) generally apply to all state agencies and often promote good management and provide checks and balances to ensure that funds are spent appropriately. Still, restrictions on year-end carry over of funds, overly restrictive state purchasing procedures, low dollar values for capitalization of equipment, and state budgeting processes all combine to impose burdens on state universities not common to private universities. Except in unusual circumstances, moreover, state regulations do not recognize the unique character of scientific equipment or the difficulties of acquiring it. In addition to high costs and short technological lifetimes, instruments with the same general specifications, for example, may have different capabilities. Further, the differences may be discernible only to experts in the field.

Fresh Approaches

Many states are seeking ways to foster technological development, and some legislatures have recognized that colleges and universities need capital equipment to compete for federal funding of research and create an environment conducive to economic development. In some states, for example, participants in the budgeting process have had the foresight to provide not just the salaries for new faculty, but also seed money and start-up funds for their research. We visited several such state universities.

The University of New Mexico received $2 million per year for five years (1980-1985) from the state for research equipment and teaching apparatus; the money was part of $5 million per year from a statewide appropriation, which was distributed to public colleges and universities by formula.

The state of Georgia set aside 1 percent of the state's higher education appropriation of $600 million for specific quality improvement programs at state schools. The $6 million allocated in 1984 was used to improve laboratory equipment. It was apportioned according to need; Georgia Tech, for example, got $1 million. Officials anticipate that similar funds will be provided each year, but the focus may change from year to year according to current needs. These funds are used for one-time expenditures without continuing budgetary commitments.

The New York State Foundation for Science and Technology has established centers for advanced technology at seven public and private universities within the state. Support for each of the seven centers is $1 million per year for four years. In addition, the state is supporting a research and development program in engineering at Rensselaer Polytechnic Institute and a major research facility for biotechnology at Cornell University.

The state of Virginia in 1984 appropriated more than $30 million for a Center for Innovative Technology to be operated by a consortium of four universities. It is designed to support research in four areas: genetic engineering, computer-aided engineering, microelectronics, and image processing. The state money is seed money; substantial industrial support is anticipated. The center will provide support for individual projects as well as a central facility.

The North Carolina Board of Science and Technology, a 15-member board established by the governor, did a thorough study of academic research equipment needs in the state. In December 1983 the board recommended that the state appropriate $73 million over five years to universities in the North Carolina system for one-time purchase of equipment and $10.9 million per year for maintenance of equipment.[1] It recommended also that the state allocate $20 million over five years to public and private colleges and universities for matching grants for equipment. As of mid-1985, the North Carolina legislature had not acted on these recommendations.

The North Carolina Board of Science and Technology is designed in part to bring together the scientific and technological resources of government, academe, and industry in the state. One result of the board's activities is the Microelectronics Center of North Carolina (MCNC).[2] It is intended to help the state develop high technology industry by enhancing the research and educational abilities of five universities and a contract research institute. The participants are Duke, Agricultural and Technical College of North Carolina, North Carolina State, the University of North Carolina at Chapel Hill, the University of North Carolina at Charlotte, and the Research Triangle Institute. MCNC thus far has been funded largely by the state and began occupying its own facilities at Research Triangle Park in 1983. Center leaders see great potential for supporting excellent research facilities in integrated circuit technology.

Another technology-fostering device is the provision at some schools of "incubation" facilities for small companies just starting out. The immediate payoff for the university is not likely to be large, but advantages could accrue in the longer term. The state of Georgia in 1980 established such a facility, the Advanced Technology Development Center (ATDC) on the campus of Georgia Tech. The center is designed to catalyze the growth of high technology in the state, and university officials say it is "a spectacular success." The center's location on campus gives companies ready access to Georgia Tech's scientific and engineering resources, both human and physical, and low-cost space for developing, testing, and manufacturing new products is also available on campus. ATDC also serves as a conduit to Georgia's other major research universities--the University of Georgia and Emory University.

Finally, a few states are permitting their public institutions to create structures that encourage public-private cooperation. In 1984, Connecticut authorized the University of Connecticut to establish a Health Sciences Research and Development Corporation which would in turn own a controlling interest in a series of research and development limited partnerships. Although implementation is just under way, this model promises to provide a vehicle that encourages private sector participation in R&D activities without the burdens imposed by direct state control.

Tax Benefits

States also support research and research equipment indirectly through tax benefits. In 34 states whose tax codes follow the federal Internal Revenue Code, tax benefits are available as specified in the Economic Recovery Tax Act of 1981 (see Chapter 5 for detailed discussion). These benefits cover contributions of research equipment to colleges and universities as well as spending on research. In four other states, the tax codes include comparable provisions but with certain variations. In addition, seven states have adopted tax credits designed to foster research and contributions to educational institutions.

CONTROLS ON DEBT FINANCING

Rising costs have led to steady growth in the universities' use of debt financing and leasing to acquire research equipment (see Chapter 4 for detailed discussion). State controls, however, have generally limited public universities' use of these financial vehicles.

Few state universities may directly incur debt except where the debt-financed facility or equipment will generate its own definable revenue stream. Even in such cases, debt financing is usually limited to capital construction. General obligation bonds and other forms of state debt commonly issued to finance buildings, highways, and other permanent improvements remain unavailable for most equipment needs (Appendix F), although research instruments may cost nearly as much and sometimes even more than permanent structures. The distinction is based on presumed useful life: financing equipment with a useful life of perhaps 5 years by means of state debt that will be carried for 30 years has traditionally been considered imprudent.

An exception here is that most states permit the financing of new (or substantially renovated) buildings to include the cost of equipping them. Equipment has generally been taken to include the instrumentation (fixed or movable) required in laboratories or other research facilities in the new or renovated building. This approach helps the university by permitting substantial equipment costs to be financed on a capital basis. On the other hand, it creates the impression that the initial instrumentation and the surrounding building will have similar long-term useful lives. State legislators and budget directors usually will accept the need to replace the instruments before the building, but not the need to replace them in only a few years. Thus, the inclusion of initial equipment with buildings in long-term capital financing can create reluctance to replace the equipment in a timely fashion.

New construction alone cannot meet the need for research equipment in academe. At most state universities, however, equipment that is not included in new construction cannot be financed through the capital route, but must be paid for out of regular appropriations. This requirement, in effect, pits needs for equipment against needs for faculty and other claims on operating funds.

Exceptions to Current Funds Only

The current-funds-only rule is not universal. To buy equipment that is expected to generate revenue, for example, nearly all states allow issuance of revenue bonds that do not constitute state debt. Interest and principal are paid from the earnings produced by the equipment. This vehicle harbors risk, however. If the revenue stream proves inadequate, the institution or the state or both may be forced to service the debt out of general funds, risk default, lose the equipment, or suffer other harm.

Another way to capitalize equipment, including research instrumentation, is pooled debt financing, where the state does not incur a general obligation. Although public as well as private institutions technically have access to pooled equipment funds, private universities have used this alternative the most. The explanation seems to lie in the schools' budgeting processes and the vagaries of state law. Private universities, at least in theory, have relatively unrestricted use of their funds and can shift them as needed to take part in pooled equipment financing. State universities, on the other hand, often are constrained by line-item or object-category budgets that lack the necessary flexibility. Some state universities have solved this problem by classifying outlays for pooled equipment funds as leases and within their power to arrange. As will be seen, however, restrictions on multiyear contracts can limit the utility of this approach.

Another exception to the current-funds-only practice is telecommunications and data processing systems. A number of states have set up debt financing programs to allow their agencies, including public universities, to acquire equipment of both kinds (see also Controls on Purchasing section below). This has been a particularly attractive area for joint ventures, as in the case of a technologically advanced teleport under development by Ohio State University with a consortium of private interests. The teleport is a telecommunications center that has a combination of several satellite-earth terminals, a switching center, and a data processing center and is used as a regional focal point for the reception and transmission of data for a number of users. In this case, the state has stepped aside to allow for the creation of a high-cost facility that would ordinarily be outside of the existing public resource base.

Private as well as public universities have benefited from state-authorized debt financing. Most states now permit private institutions to participate in tax-exempt bond issues that impose no general financial obligation on the state. Many state legislatures have established financing authorities for higher education facilities that are empowered to issue bonds to finance capital projects at private universities. In a growing number of states the proceeds may be used to buy equipment not part of a construction project. California is the primary example of a state that has aggressively promoted pooled issues, the proceeds of which could be used for equipment as well as facilities.

Financing research equipment through debt that is not a general obligation of the state is an important development as more and more states find themselves at or near the statutory or constitutional limit on the money they may owe.

Leasing

Leasing equipment to spread its cost has become common among research universities. Public universities in many states, however, face statutory limits on the duration of contracts, including leases. Such limits, often based on the appropriations period (usually one or two years), restrict the schools' ability to arrange advantageous leases. Even where a long-term lease can be negotiated, it must by law be cancelable annually or biennially, which increases the risk to the lessor and, therefore, the cost to the lessee. Current exceptions that allow multiyear leases are commonly limited to real property or special categories of fixed equipment, particularly telecommunications.

CONTROLS ON PURCHASING

State controls on purchasing and procurement significantly constrain the acquisition of research equipment. Nearly every state requires its public universities to conform to at least some of the standards and procedures for buying equipment that apply to all state agencies. Such requirements include publication of specifications, approved bidder lists, competitive procurement, and the award of contracts to the lowest responsive bidder. Controls on purchasing and procurement usually apply with equal force whether the equipment is bought with current funds or through capital financing.

State controls are frequently more restrictive than federal regulations. They may, for example, require orders to be processed and approved through a statewide purchasing agency, a procedure that often delays acquisition and isolates investigators from discretionary judgments that are essential to the purchasing process.

State purchasing requirements tend to be designed to deal with the acquisition of routine and general-purpose goods: automobile tires, cleaning supplies, and the like. Although often not drafted with the requirements of sophisticated scientific research instrumentation in mind, they often subsume those acquisitions as well. This problem becomes particularly severe because procurements are defined in generic terms; in the case of many items required in the functioning of state government, such a process is both reasonable and indeed an efficient way to control expenditures. With state-of-the-art scientific apparatus, however, the brand-to-brand difference may be far from insignificant. Purchasing officers are primarily interested in saving money, whereas the scientist's main goal is to perform research. The scientist looks for characteristics that might indicate that one product is superior to another; difficulty can arise when university or state purchasing officers are not persuaded of, or do not understand, these subtle differences in instruments or other equipment. Additionally, purchasing officers sometimes do not understand the time constraints on scientific experiments. When purchasing officials fail to see that buying scientific instruments or their components is different from buying tires and batteries, misunderstandings and a degree of conflict are inevitable. Such problems are not confined to state colleges and universities, but they are less common in private institutions.

Competitive bidding on scientific equipment may result in substantial discounts or the inclusion of additional features, spare parts, or expendable supplies, which is good for both the university and the sponsor of the research. But while the Office of Management and Budget Circular A-110 and the Federal Acquisition Regulation require competitive procurement where practicable, state law almost without exception mandates competitive procurement by public universities. In some states, the procurement procedures apply with full force to purchases by state universities even with nonstate funds.

Some states permit exceptions to normal procurement standards. Competitive procurement may not be required, for example, below a specified dollar value and where the item is available from only one source or is needed in an emergency. Often, however, the threshold is so low ($100 in some states) that little scientific equipment falls below it. One public university must ask for bids on all equipment costing more than $700, even when only one vendor can meet the specifications. While a sole-source exemption is useful in principle, its value often is limited severely by narrow definitions of the kinds of acquisitions and the circumstances of their procurement that trigger such treatment. The investigator's view that one of several possible suppliers offers the best or most suitable device, for example, is rarely enough to invoke the exemption. The adequacy of the alternatives is usually determined by state purchasing authorities far from the scene and with little or no scientific background.

Exceptions based on emergency need are likewise of limited utility. State rules tend to define emergencies in terms of protecting health and safety and public property. Thus, a contract to replace a storm-damaged roof may be let promptly and noncompetitively, but a request to acquire equipment noncompetitively to meet a research deadline is likely to be rebuffed. Strict application of state puchasing controls in this manner is particularly troublesome: opportunities for sponsored research often come on relatively short notice, and the ability to pursue the work on a timely basis may be critical to obtaining the grant or contract.

State equivalents of "domestic content" laws also can present problems. These laws give in-state vendors preference in the award of contracts for equipment and services. Although a growing number of states exclude scientific equipment from home-state preference rules, the exceptions generally remain narrow or depend on approval by state purchasing officials.

Public universities have sought to ease the negative effects of state purchasing controls in several ways. One is the use of a university-controlled foundation as a conduit for acquiring research equipment with nonstate funds. In a number of states, however, the ability of such entities to operate outside the framework of state control has been challenged. Some states have subjected university foundations to the same purchasing and procurement rules that apply to the universities, particularly where the foundation is viewed as quasi-public. University foundations not created by statute are less likely to be subject to state control, but some jurisdictions have sought to require even these foundations to adhere to state procurement policies. There are indications that this policy is changing, as more and more states recognize the competitive advantages of allowing their public institutions to create nonpublic subsidiaries to conduct and reap the benefits of scientific research.

State procurement requirements may even extend to private universities that rely on funds from state-sponsored bond issues or debt, direct grants, or contracts. In such cases, the acquisition of equipment and services generally must conform to the state purchasing act, although some states follow the federal example of requiring general adherence to the principles of the procurement rules, but not necessarily to every detail.

States frequently apply particularly strict purchasing controls to data processing and telecommunications systems. These special controls were imposed after many state agencies invested considerable sums in systems that turned out to be incompatible or redundant. The imposition of uniform standards and selection criteria has been reasonably successful but is not always suited to computer and telecommunications systems for use in academic research. In consequence, a number of states have exempted such equipment from special restrictions, and many allow waivers of uniformity standards.

CONTROLS ON USE OF EQUIPMENT

Public universities are commonly governed by "public purposes" language in the state constitution or statutes that limit their freedom to enter agreements with for-profit entities. In terms of the acquisition and use of research equipment, such restrictions place the public university at a disadvantage relative to private universities.

This issue raises several complex questions. First, the very concept of public purpose versus private use is not uniformly defined. In some states the determining factor is the nature of the use; in others it is the identity of the user. Sponsored research is generally viewed as a public purpose. Where the sponsor makes separate use of the equipment, however, or obtains unique rights to results obtained with it, it has been asked whether a private purpose has not overtaken the public one. Questions about private use raise anticompetitive issues as well, owing to the theory that use of state-funded property and equipment for private purposes gives the user an unfair advantage over private competitors.

As a result of these constitutional and statutory limitations, some public universities have turned to the creation of structural appendages that are technically nonpublic and may even be profit making. Several states are actively encouraging this approach in recognition of the need to free their institutions from the constraints imposed on other public agencies, so that they can compete more effectively in the high-technology marketplace. The creation of the separate University of Connecticut Health Sciences Research and Development Corporation was applauded by the state as a means of strengthening the competitive position of the university. Like the university foundations, however, these appendages are not immune to the risk of encouraging the state to assert jurisdiction over them.

FINANCIAL FLEXIBILITY

While state controls on financing, purchasing, and using research equipment are important concerns, many public colleges and universities find that their ability to acquire and manage equipment depends additionally on the degree of financial flexibility granted them under state law and regulations. State universities, for example, may have difficulty transferring funds between budget categories (e.g., personnel, capital, operations) to take advantage of opportunities such as participation in pooled equipment funds. They may be unable to carry over unexpended funds from one budget period to the next. Many state universities are not permitted to pay matching costs for equipment from tuition income or patient fees and so draw on gift funds or advance unrestricted funds.

Financial Control Practices

Financial control practices have been assessed[3] in terms of institutional autonomy and grouped into two models: the state agency model and the corporate/free market model.

Key features of the state agency model are as follows:

- All funds (from federal and private sources as well as the state) flow through the state treasury and must be reappropriated by the legislature.
- All procurements are subject to standardized requirements and centralized processing.
- Detailed spending requests focus on objects of expenditure. Deviations from budgets must be approved in advance and reported.
- Unexpended funds are returned to the state treasury.
- Changes with long-term fiscal impact are monitored.
- Purchasing, construction, and other costs of operations flow through the state government.
- Oversight is focused on process (adherence to regulations) as opposed to product (quality of research and education).

Other features may include state control of indirect cost recoveries from the federal government and restrictions on the disposition of state-owned surplus property. Indirect costs are commonly collected by the state and reallocated to the schools to a degree that varies by state. In many state universities, equipment purchased with federal funds becomes state property after title has been given to the university and is then subject to all of the arcane regulations for state property.

Key features of the corporate/free market model are as follows:

- Institutions have complete control of funds, whatever the source, including indirect cost recoveries.
- State appropriations are made in block form, and the institution has unbridled authority to contract for goods and services from outside sources.
- Oversight is focused on product as opposed to process.
- Auxiliary organizations and support activities are not subjected to state controls.

A recent study[4] examined the financial flexibility of 88 Ph.D.-granting public universities in 49 states in terms of the characteristics of these models. The results showed no differences in administrative costs, salaries, or complexity that correlate with the degree of state oversight. Differences were associated rather with the size of the university, the presence of a medical/hospital complex, graduate enrollment, unionization, and level of state funding.

More importantly, public universities with greater degrees of autonomy tend to depend less on state appropriations and to raise more of their support from other sources, federal and private. This finding suggests that relief from state regulations frees faculty and administrators to turn their attention to more productive work, including development and sponsored research activities, investment strategies, and long-range financial planning (fostered by biennial budgets and retention of unexpended balances).[5] Improvements in these areas can directly benefit the capacity of public universities to acquire and manage scientific equipment.

Deregulation in Kentucky

The state of Kentucky deregulated its institutions of higher education in 1982, with significant benefits.[6] Kentucky had been a "strong governor" state with centralized accounting and procurement for all of higher education. The state commissioned an independent study that concluded in part that state regulation was a significant barrier to effective management of the schools because of frequent duplication of procedures. The study led to the passage of the Universities Management Bill (H.B. 622). The bill afforded changes in regulation of purchasing, capital construction, accounting and auditing, payroll, and affiliated corporations and foundations. Each school was given the option of implementing any or all of the provisions of H.B. 622.

The primary effect of the bill was decentralization of the administration of higher education, enabling the schools to manage their own affairs. The move has produced significant savings for both the universities and the state by eliminating duplication and freeing administrators for more productive work.

The University of Kentucky, for example, estimates that it will save $500,000 per year by handling the purchasing function itself; $90,000 of the savings comes simply from being able to avoid the state stores' 9 percent markup. By assuming the responsibility for capital construction, the university sharply reduced the time required to appoint architects and award contracts; it awarded $7 million in contracts between July 15, 1982, and March 1983 with an estimated saving of $445,000 resulting from the streamlined procedures. Smaller public institutions that do not have sufficient administrative staff and resources to exploit the provisions of H.B. 622 on their own are forming consortia to do so.

Failure of schools to comply with the provisions of the act once they elect to follow it, or lack of cooperation among schools, could jeopardize the changes brought by H.B. 622. During the first two years under the act, however, the results were very favorable. Depending on local circumstances--the number and size of public colleges and universities and the degree of centralization--deregulation as practiced in Kentucky could be beneficial in other states.

RECOMMENDATIONS

The conflict in the roles played by state governments vis-a-vis academic research equipment is inherent to a degree in the relationship between the states and their public colleges and universities. Nevertheless, we believe that in many cases the states could combine their broad roles as funder and regulator more rationally and could otherwise help to ease the schools' serious problems with research equipment.

We recommend...

1. **That states assess the adequacy of their direct support for scientific equipment in their public and private universities and colleges relative to support from other sources and the stature of their schools in the sciences and engineering.** The states cannot displace the federal government as the major funder of academic research equipment, but judicious increases, on a highly selective basis, could be extremely beneficial to the scientific stature of states while simultaneously increasing the effectiveness of funds available from federal and industrial sources.
2. **That states grant their public universities and colleges greater flexibility in handling funds.** Desirable provisions would permit schools to transfer funds among budget categories, for example, and to carry funds forward from one fiscal period to the

next. Greater flexibility would not only improve the universities' ability to deal with the problems of research equipment, it would also be likely to provide direct savings in purchasing and would free academic administrators to discharge their responsibilities more efficiently.

3. **That states examine the use of their taxing powers to foster academic research and modernization of research equipment.** Tax benefits available under the federal Internal Revenue Code are also available in 34 states whose tax codes automatically follow the federal code. Relatively few states, however, have adopted tax benefits designed to fit their particular circumstances.

4. **That states revise their controls on procurement to recognize the unusual nature of scientific equipment and its importance to the research capability of universities.** Scientific equipment often is highly specialized. Instruments that have the same general specifications but are made by different vendors, for example, may have significantly different capabilities. The differences, furthermore, may be discernible only by experts in the use of the equipment. Desirable revisions in state controls would exempt research equipment from purchasing requirements designed for generic equipment and supplies, such as batteries and cleaning materials; would vest purchasing authority for research equipment in individual colleges and universities; and would not apply rules beyond those already mandated by the federal government.

5. **That states consider revising their controls on debt financing of scientific equipment at public colleges and universities to permit debt financing of equipment not part of construction projects, recognize the relatively short useful life of scientific instruments, and relieve the one- and two-year limits on the duration of leases.**

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3

The Universities' Role in the Acquisition and Management of Research Equipment

INTRODUCTION

The universities' involvement with scientific equipment entails many activities in addition to the conduct of research. Broadly, universities provide the administrative and physical infrastructure needed to support research that warrants the acquisition of instruments and other equipment. More specifically, in varying degree, the universities provide money for equipment from their own resources, from gifts they solicit, and from various forms of debt financing; handle the purchasing process; pay part or all of the costs of operation and repair; maintain inventories; help to optimize the sharing of equipment; and handle disposal of equipment no longer useful or needed.

The universities' approach to these functions is conditioned by characteristics unique to themselves. Usually they perceive that their primary duty is to personnel--students and the faculty needed to teach them. Also, authority in U.S. universities is highly decentralized to foster the freedom of inquiry deemed essential to first-rate research and teaching. The majority of support for academic research and the associated equipment is obtained through competitive proposals prepared by individual faculty members or small teams of investigators. Systematic programs planned well in advance are the exception, not the rule. Much of this support comes from federal agencies, so universities must use and account for equipment in accordance with federal regulations. State universities in addition must comply with state regulations.

These and other characteristics of universities and their research call for procedures in acquiring and managing scientific equipment that generally differ from practice in industry and government. In this chapter we assess academic practice, identify opportunities for improvement, and consider industrial and governmental procedures that might be relevant to academe.

ACQUISITION OF RESEARCH EQUIPMENT

Sources of Funds

Funds for academic research equipment come from the federal government, from the universities themselves, from state governments, and from business and other private sources (state funds are rarely available to private universities). The contributions of each are indicated by the NSF National Survey of Academic Research Instruments, which covers major instrumentation systems in use in 1982-1983.* The data show that federal agencies funded 54 percent of the cost of acquiring these systems, universities 32 percent, state governments 5 percent, business 4 percent, and other sources 5 percent (Table 3, Chapter 2). Other NSF data show that nearly two-thirds (63 percent) of expenditures for academic research equipment in 1983 was funded by federal agencies (Appendix B).

Funds supplied by universities may involve some form of debt financing, which is covered in Chapter 4. Also, the Economic Recovery Tax Act of 1981 permits companies to take special tax deductions for scientific equipment they donate to universities; Chapter 5 includes guidelines for universities that wish to develop a strategy for obtaining such donations.

Competitive Proposals

Private and public universities alike rely principally on competitive proposals, subject to some form of peer review, to obtain funds for research equipment. The decision to compete for funds is made by the scientist who wishes to do the research, and the outcome of competition for federal funds cannot usually be predicted with confidence. A matching contribution toward equipment may be expected from the university (see later discussion), but usually it is insufficient without additional resources from a grant, contract, or gift.

If the equipment costs more than can reasonably be expected in a normal research-grant budget, scientists usually seek supplemental funds from the department, college, or university, from other funding agencies, and from colleagues who have grant money available and need access to the equipment.

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*Systems in use in these years may have been purchased in earlier years.

Scientists with common interests join forces voluntarily to seek funds for equipment at most of the universities we studied. Such cooperative efforts may involve faculty in different departments and even in neighboring universities. Funding agencies support these joint efforts because of the quality of the collaborating faculty; further, each collaborator has apparatus and techniques that augment the shared equipment. This mode of operation is common, for example, at the Materials Research Laboratories supported by the National Science Foundation.

Several scientists with common interests and needs may be able to obtain support for shared instrument facilities outside the normal single-investigator research-grant process. NIH, NSF, DOD, and DOE all have instrumentation programs that encourage or require sharing by several qualified scientists. These programs often encourage or mandate a university contribution to the cost of the equipment (see Chapter 1).

The normal goal of a competitive instrument-acquisition effort is to win sufficient funds to buy the basic instrument after university contributions and vendor discounts have been exercised to the limit. Desirable features missing from the basic instrument are acquired through funding efforts in subsequent years. Often, however, buying the complete package is much more economical than having components installed later in the field. If the saving is obvious, the federal agency and the university may supplement their funding awards to achieve the overall economy.

We found that scientists recognize these efforts to win grant funds, pool resources with colleagues, and convince department heads and deans of the value of a university contribution as normal and necessary procedures for obtaining research equipment.

Start-Up Costs

The competitive grant system does not provide funds for equipment that must be acquired for newly hired faculty members. Most universities we contacted bear some such start-up costs, and these costs for laboratory scientists can require major financial commitments by universities. They may consume reserves equal to the endowment needed to support a faculty salary permanently.[1] Several universities queried estimated instrumentation start-up costs at $25,000 to $250,000, depending on the faculty member's discipline and academic level. Even higher costs may be entailed by hiring faculty already established as outstanding investigators. A major eastern university we visited incurred initial costs of about $2 million when it hired an established professor of chemistry.

High initial costs of equipment have discouraged universities from entering certain research areas, such as work involving synchrotron radiation, which is now available only at national shared facilities. Universities also have hesitated to enter fields where equipment is too costly to obtain for one investigator and is not readily shared because of problems such as contamination in some kinds of analytical chemical apparatus.

A specific example of the exclusion of universities from research by high start-up costs is molecular beam epitaxy (MBE), a means of growing new types of materials that can be controlled at the atomic scale. MBE is producing exciting new physics (e.g., the fractional quantum Hall effect) and promises to produce new types of semiconductor devices and very high speed transistors. A number of industrial laboratories are working with MBE, but the cost of the equipment--up to $1 million--has barred all but a few universities from research in this field.

Raising start-up funds typically involves departmental, college, and universitywide administrators. Funds are drawn from operating budgets and augmented by endowments, gifts, and flexible resources such as the NIH Biomedical Research Support Grant. The American Chemical Society's Petroleum Research Fund, the Sloan Foundation, EXXON's Centennial Engineering Education Program, Atlantic Richfield's Aid to Education Grants, and the recent NSF Presidential Young Investigator awards help cover start-up costs in certain fields. The NIH Research Career Development Award covers salary and thus helps with initial costs, since salary, as well as the costs of laboratory facilities, usually is the responsibility of the university.

Methods of allocating funds for faculty start-ups will vary with the organization of the university, but faculty involvement can help by supplying an understanding of the special needs of the research community. At a midwestern university we visited, the task is handled by a board of eight senior faculty members. The board allocates about $2.5 million per year to faculty in research support. (The university spent $96 million for separately budgeted R&D in 1982.) A significant portion of this amount is used to acquire equipment, and departments may apply to the board for start-up funding for new faculty.

Matching Funds

Federal agencies that award funds for research equipment may expect or require the university to make a matching contribution toward the total cost (see Chapter 1). Such matching is distinct from the cost-sharing arrangements in which universities pay part of the operating costs of a research project. Matching funds play a supporting rather than a leadership role in decisions to compete for grants, since the university makes the award only if the scientist wins the competition.

Many state universities are not permitted to pay matching costs from instructional monies. Instead, they draw on gift funds or advance unrestricted funds. Gift funds are used also to pay start-up costs for new faculty, and private donors may be willing to give matching funds because of their added leverage.

Several universities told us they had raised matching funds from donors and philanthropic trusts. The added leverage and the appeal of some current technology help scientific equipment to compete with other would-be beneficiaries, such as athletic programs and hospitals. Several universities also cited the efficacy of fund drives for specific items of research equipment.

Decisions on providing matching funds are made differently among universities. At some small universities that have little flexibility in departmental or college operating budgets, the chief executive officer makes decisions on matching (as well as start-up funding). In other cases, the deans make such decisions and often delegate budget planning to the departments so the decisions reflect departmental priorities. At some universities, a faculty committee allocates the available funds.

Attitudes toward matching also vary. Some universities voluntarily offer matching on all major instrument proposals in the hope that it will improve their competitive stance. Other universities pursue more conservative practice by matching only when it is a condition of receiving an award. We encountered some instances where matching funds were so scarce that faculty did not seek grants known to have a mandatory matching requirement.

From the faculty perspective, the major reason for an institution to provide matching funds is to acquire the equipment and pursue the research described in the proposal. Faculty also perceive that financial endorsement by the university may make a proposal more competitive. As implied above, however, some universities would rather use discretionary funds in other ways, Also, universities often are not certain that matching funds are necessary to obtain the grant; they see a need for greater clarity in agencies' statements of their matching requirements.

Multiyear Payment

When the outright cost of a piece of equipment is more than the funding agency can accommodate in one year, an investigator may request an advance against the university's future-year capital funds. We encountered a few instances where the sponsoring agency had approved a proposal to buy an instrument with funds advanced by the university and recovered by charging annual installments to the grant as direct costs. The interest foregone is not recoverable by the university as a direct or indirect cost. While the agency may agree to the principle of the plan, it does not guarantee future-year funding. Thus the university subsidizes the purchase and assumes significant risk. The burden of negotiation is also substantial for everyone involved, and the method is not widely used.

Another way to obtain equipment before the full purchase price is in hand is to combine funds from two successive years. With first-year funds secured and second-year funds promised, the university may be able to deal with vendors so that payment can be spread over several years without finance charges. We found that scientists at some universities make such arrangements without help from university officials. Faculty members said they would like to be able to do so more formally by putting half the cost of a piece of equipment in each of two years of a proposal. We are not aware of prohibitions against combining funds from successive grants, but the perception is that agency officials are not sympathetic to such arrangements.

When vendor and scientist enjoy mutual trust and confidence, some vendors have agreed to multiple-year payment plans without formal leasing and without interest charges. This practice is costly to the vendor, but it may help to consummate a sale.

Leasing

Leasing is a standard way to spread payment for equipment over several years. We found, however, that principal investigators prefer to find ways of obtaining apparatus without resorting to leasing because the ensuing costs reduce flexibility in future years of research by obligating grant funds to cover lease costs. Carrying charges are high (typically above prime rate), and the vendor is less aggressive in discounting if a lease must be arranged. Further, leasing, like other kinds of debt financing, is practical only when income is available to meet the payment (see Chapter 4). Although universities commonly lease equipment such as copying machines and computers, they lease only a very small fraction of research instruments.

Lease payments, in contrast to equipment purchases, are normally charged with indirect costs. This further increases the costs of leasing to awards, relative to direct purchase, by a percentage equal to the indirect cost rate. Some universities, however, have dealt with this problem by not charging indirect costs on leased equipment. Excluding such payments from the indirect cost base requires negotiations with the auditors.

Many states forbid multiyear leases unless a nonstate source provides the payments; some state schools have created foundations designed to overcome this and other regulatory barriers. At Georgia Tech, for example, multiyear leases are handled by the Georgia Tech Research Corporation (GTRC), a private, not-for-profit entity. All external research funds at Georgia Tech, except funds provided by law, are awarded to GTRC, which also retains part of the indirect cost funds generated in research projects. GTRC in part buys and leases equipment and provides it to individual research programs. This procedure permits Tech to get research equipment into the laboratory of the individual faculty investigator more quickly, to return obsolete equipment and replace it by newer models, and to spread equipment costs over multiple years.

We cite two other examples of leasing that we encountered. One involved a 500 MHz nuclear magnetic resonance (NMR) spectrometer acquired through a lease with an option to purchase because the funding agency would provide only $138,000 per year toward the acquisition of the equipment (an NMR of this kind typically costs about $750,000 fully equipped). The second example was a similar experience in the acquisition of a mass spectrometer and an NMR spectrometer.

The corporate laboratories we visited preferred purchasing over leasing because businesses receive tax benefits from research investments and from depreciation allowances on purchased equipment. They did lease some research equipment, such as NMR and mass spectrometers and computer equipment when it was being evaluated for long-term use.

One national laboratory indicated that lease to ownership is an accepted approach when capital funds are unavailable. The primary consideration in selecting the financing method is the interest charge. Another national laboratory did a lease versus purchase analysis for a computer. With direct purchase defined as 1.0, the other cost ratios were as follows: lease 2.01, lease with option to purchase 1.18, third-party lease to ownership 1.17, and lease from vendor to ownership 1.40. Such analyses are valuable and are done by many universities when they are considering leasing equipment.

The Purchasing Process

Universities' purchasing procedures should help scientists obtain reliable, quality equipment in a timely and economical manner. For purchasing procedures to work most effectively, purchasing agents and research faculty must understand each others' needs. Misunderstanding can lead to delays in acquiring equipment, which can result in higher prices and can also severely hamper research.

When buying federally funded equipment, universities must comply with federal acquisition policies prescribed particularly by OMB Circular A-110, Attachment O, for grants, and the Federal Acquisition Regulation for contracts (see Chapter 1). State universities additionally must comply with state purchasing regulations (see Chapter 2). State regulations often are more restrictive than the federal regulations, and private universities generally enjoy substantially greater flexibility than public universities in purchasing scientific equipment.

Purchasing agents can be extremely helpful in the acquisition process. Creative and aggressive purchasing agents can negotiate volume discounts and payment alternatives that provide substantial savings on grants and contracts. We were told of universities that have purchasing agents knowledgeable and concerned about the issues involved in acquiring scientific equipment. Many faculty members at other schools, however, indicated that uninformed purchasing agents are a significant problem. The North Carolina Board of Science and Technology recommended in December 1983 that the state purchasing organization arrange continuing education programs for state purchasing agents who handle scientific equipment and assign an existing purchasing agent to specialize in scientific equipment; the board recommended also that public institutions make a special effort to educate faculty in purchasing procedures for equipment.

MANAGEMENT OF RESEARCH EQUIPMENT

We examined academic management practice in budgeting and planning for research equipment as well as in operation and maintenance, inventory systems, and replacement and disposition. The nature of universities--their decentralized organization and unique system of shared governance--doubtless impedes orderly management in the corporate style. Still, we observed that some practices on campus clearly ease problems with equipment more effectively than others, so greater attention to management would seem to be in order. Our findings indicate that universities would benefit from stronger efforts to improve their internal communications. Public universities are obliged by state regulations to deal with equipment-management matters that do not normally concern private universities; these additional complications are covered in Chapter 2.

Budgeting and Planning

Budgeting and planning in industry and in universities differ significantly. In industry, budgeting and planning often start several months (or years) before the year in which expenditures are to be made; industrial laboratories have reasonable control of funding, planning, and scheduling, subject only to corporate strategies and decisions. Universities are differently situated. Although they routinely plan instructional programs in advance of the academic year and capital building programs several years in advance, most of their scientific equipment is funded from competitive grants and so is not readily amenable to planning. While the competition is deemed necessary to assure that the best research is supported, barriers to planning are inherent in the system of competitive proposals.

Usually the outcome of a grant proposal is not known until a few weeks before the research is started. Some agencies, in fact, are unable to meet grant renewal and award deadlines, and universities often take risks by carrying *minimum* costs to keep a research team together while awaiting the final terms of an award. The short term (seldom more than three years) of grants and contracts also makes planning difficult. Further, the individual researcher is always subject to congressional or agency decisions on the continuation and level of funding of federal programs. Investigators at several schools cited decisions by federal agencies, as a result of congressional cuts, that required significant changes in plans to acquire new equipment as well as in management practices for existing equipment.

The larger block grants, such as NIH program project grants and grants to NSF regional and national facilities, offer more opportunity for planning (see Chapter 1). The involvement of more scientists with a common purpose, a strong incentive for sharing, and longer term (five year) awards all encourage planning. Several universities cited such core support grants as particularly useful in providing stability, permitting some mid-term planning, and addressing the equipment problem in an orderly fashion.

Universities appear to be increasing their attempts to formalize equipment funding processes with faculty involvement in allocation of university resources. Two universities told us of internal capital funding and resource allocation boards that attempt to identify specific needs for capital equipment and plan to meet them. No university, however, described a process as long or as detailed as those in national laboratories or in industry.

One industrial department head described a model designed to calculate the costs of equipping a typical engineer with capital items. The model does not consider inflation or equipment upgrade, but does provide for replacing equipment after three years; it calculated start-up cost at $145,000 to $160,000 per engineer. The model was described as having several advantages: it eased the calculation of equipment requirements; once accepted, it made funding for capital equipment easier to obtain from higher management; and it aided both morale and productivity. We found no university that can exercise similar control over funding for research equipment. We feel that most universities, however, can better organize their procedures for supplying matching funds and establish clear criteria for allocation of such funds.

Investment in People

Universities, if forced to choose, generally will use available funds to retain faculty and graduate students in preference to buying equipment. This attitude is in keeping with the schools' dual mission--education and research--which emphasizes people and requires the long view. To build, or to rebuild, a faculty takes decades. Industrial laboratories tend to be more ready to lay off personnel, despite the potential impact on their capabilities, and will invest in automating research equipment. Automation is not as essential in universities, where graduate students change samples over nights and weekends. Universities report risking funds to keep research teams together for a time between grants in the hope that support for them will materialize; the funds so invested are invariably for personnel, so equipment budgets may be sacrificed to keep a team intact.

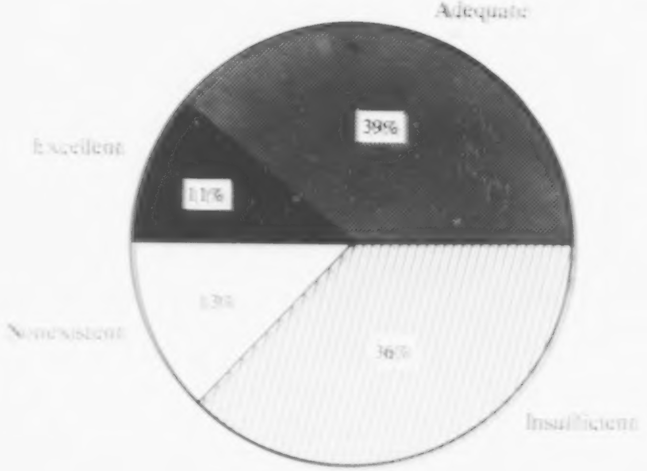
Operation and Maintenance of Research Equipment

Operation and maintenance of academic research equipment are serious management issues at every university we visited. Some universities do an excellent job of keeping research equipment in good repair and have qualified staff to operate it when appropriate; others leave much to be desired. All find the task a strain on their resources.

The NSF instrument survey included a departmental/facility assessment of instrumentation support services. Some 49 percent said their services were inadequate or nonexistent, 39 percent said they were adequate, while only 11 percent said they were excellent (Figure 6).

Another survey, submitted to the National Science Board, indicated that 72 percent of the respondents relied primarily on

FIGURE 6
Department/Facility Assessment of
Instrumentation Support Services
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

departmental support services (computer and other electronic repairs, glass shop, machine shop, mechanical shop, other general repairs, etc.).[2] The usage of support services was higher in public than in private universities.

Over the service life of equipment, total operating and maintenance costs will frequently exceed the purchase costs. One of the NSF Materials Research Laboratories has found over the years that operation and maintenance of its central facilities cost about 1.5 times the amount it spends in the same year on new equipment. NSF data on departments/facilities show that about 15 percent of annual instrumentation-related expenditures in 1982-1983 were devoted to maintenance and repair (Table 5).

We encountered many cases where universities had to decline gifts of research equipment because they could not afford to operate it. One university, for example, declined a gift of computer-aided design equipment because it would have cost $170,000 per year to operate.

Recognition of Costs

Not all university administrators appreciate the high costs of maintaining and operating research equipment, nor do they budget for them. One state university, for example, received $10 million over two years from the state government to purchase equipment (not all was used for research equipment; some went for teaching equipment). Adequate funds for maintenance and operation were not available in the university's budget, even when the equipment was used for teaching, nor was the faculty attracting sufficient grant money to meet these costs. In consequence, much of the equipment is not regularly available for use.

Technical Support Staff

Technical support staff is an important issue. Many academic departments traditionally have not used research technicians; rather, the practice has been for graduate and postdoctoral students to work with faculty repairing equipment, often at considerable expenditure of time. While some of this activity is educational, a great deal of it is not and distracts effort from research. In any event, as research equipment becomes more sophisticated, more permanent technical support people become necessary. It can be difficult, however, to attract competent support people to universities. They are usually less well paid than in industry and do not find the same attractions at a university as the faculty do. Small numbers of faculty frequently

TABLE 5 Instrumentation-Related Expenditures in Academic Departments and Facilities in 1982-1983, by Field (Dollars in Millions)

	Total	Purchase of Research Equipment $500 or more	Purchase of Research-Related Computer Services	Maintenance/ Repair of Research Equipment[a]
Total, Selected Fields	$640.6 (100%)	$414.5 (65%)	$121.3 (19%)	$104.8 (16%)
Agricultural Sci.	40.6 (100%)	28.4 (70%)	7.3 (18%)	5.0 (12%)
Biological Sci., Total	192.3 (100%)	132.4 (69%)	27.8 (14%)	32.2 (17%)
Graduate Schools	79.0 (100%)	51.8 (66%)	13.2 (17%)	14.0 (18%)
Medical Schools	113.3 (100%)	80.5 (71%)	14.5 (13%)	18.3 (16%)
Environmental Sci.	49.6 (100%)	33.4 (67%)	6.9 (14%)	9.3 (19%)
Physical Sci.	151.3 (100%)	91.2 (60%)	31.9 (21%)	28.2 (19%)
Engineering	146.6 (100%)	86.5 (59%)	41.3 (28%)	18.8 (13%)
Computer Sci.	29.7 (100%)	19.7 (66%)	3.6 (12%)	6.4 (21%)
Materials Sci.	12.4 (100%)	9.6 (77%)	0.6 (4%)	2.3 (18%)
Interdisciplinary, not elsewhere classified	17.8 (100%)	13.3 (75%)	1.9 (11%)	2.6 (14%)

[a] Estimates encompass expenditures for service contracts, field service, salaries of maintenance/repair personnel, and other direct costs of supplies, equipment, and facilities for servicing of research instruments.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic Research Instruments and Instrumentation Needs.

allocate the cost of a technician's salary among their grants, but grant or contract funds are often so uncertain as to bar long-term career stability for technicians. The block funding and centralized operations of the NSF Materials Research Laboratories are an excellent solution to this problem for research that can be funded in this mode.

User Charges

It is common practice to attempt to cover the salaries of equipment-support personnel and the costs of operation and maintenance through user charges. The amount of use is often hard to predict, however—new facilities often require some time to reach a full level of use—which makes it difficult to set appropriate rates. High user fees tend to reduce the use of equipment and can actually reduce total income to the facility and make it available only to the best funded potential users. We heard frequently that user fees considered optimal by the people running the facility do not cover the costs of operation. We rarely found that user fees paid the operating costs of shared, central-facility research equipment. The NSF-supported Materials Research Laboratories have much experience with this type of operation; typically, they find it necessary to subsidize 20 to 30 percent of the operating and maintenance costs of their central facilities from core grants.

Regulatory Issues

A general difficulty with user charges is that what is true at one institution is not necessarily true at another, although both are operating under the same federal regulations. The problem lies in the inconsistent and often conservative interpretation of the regulations by both federal and academic officials (see Chapter 1).

Specifically, we encountered a faculty member at one university who had been able to charge his various research grants in advance for access to research equipment, and so knew at the beginning of the operating period that the full operating costs would be covered. When a similar prepayment or subscription plan for instrument use was tried at another university, the federal auditors would not allow it. Whether the difference was due to a substantive difference of process (of which we are unaware) or to the way the plan was explained to the auditors, we were unable to ascertain.

OMB Circular A-21 prohibits providing use of equipment to anyone at lower cost than to government grants or contracts. This prohibition often interferes with maximum use of equipment--it is not possible, for example, to provide low cost or free use of research equipment for instructional purposes while billing federal grants and contracts at a higher rate (low rates can be charged during low-use periods, such as from midnight until 6 A.M., so long as all users are treated equally). One university pointed out a common solution to this problem for computing centers. Like every other academic computer center we encountered, the one at this school required a university subsidy to break even. The university budgeted this subsidy as an allocation to users who could not afford the full rates, rather than applying it to an across-the-board reduction of rates.

Physical Infrastructure

The operation and maintenance of research equipment depend on the physical infrastructure for research. The infrastructure includes fume hoods, electrical supply and insulation, sound isolation, air conditioning, numerous kinds of support equipment, such as oscilloscopes, leak detectors, and machine tools (e.g., lathes and milling machines), service and maintenance facilities, as well as the buildings that house research laboratories.

We saw many 1950s vintage oscilloscopes at universities and relatively few modern ones; most of the machine tools in universities were acquired well over 20 years ago, often as surplus, and are at the point of needing replacement. When funds are scarce, federal agencies tend to support equipment that will be used directly in the research they fund; the less glamorous items are essential, but not as easy to find support for. Federal agencies once funded this kind of equipment but no longer support its inclusion in project budgets. The universities might buy it and recover a portion of the costs attributable to organized research through the indirect cost pool, but universities are under intense pressure to hold down indirect costs. Also, cost recovery takes 15 years at the federal use allowance of 6 2/3 percent per year.

University Maintenance Facilities

None of the universities we visited had the service and maintenance infrastructure found in most large government and industrial laboratories. Many faculty expressed the desire for some university facility to maintain research equipment, but we found successful examples of such facilities to be rare. The one universitywide facility that seems to work well is Iowa State's REAP program (see discussion below under Optimization of Use).

We think there may be several reasons for this situation. Where individual research grants pay most of the costs through user charges, the uncertainty of income is a barrier. A university is not typically a geographically focused enterprise, so a central maintenance facility may be practical at some institutions and not at others. Also, the increasing complexity and specialization of research equipment means that service people must be correspondingly specialized. The result is a greater tendency to rely on manufacturers' service representatives. This solution may be best in large urban areas; in more isolated areas, faculty may have to service the equipment themselves or rely on university resources. University-subsidized facilities can relieve individual faculty and departments of financial responsibility they may have difficulty meeting.

Service Contracts

Service contracts for most research equipment usually cost about 10 percent of the purchase price per year. When equipment is shared among a small number of faculty and research grants, it is common practice to allocate the costs of a maintenance contract. We learned at some universities, however, that investigators could not afford service contracts on equipment and were gambling that costly service would not be needed. Some manufacturers will give discounts on service contracts if a university issues a purchase order for servicing all its equipment on the campus; we learned of discounts on the order of 20 percent. Manufacturers also may give discounts for payment at the beginning rather than the end of the service year; in one instance the discount was 10 percent.

Inventory Systems

A reliable inventory of university-purchased research equipment can be used to ensure proper recovery of indirect costs (see Chapter 1). Many of the universities we studied had paid little attention to inventory systems; most have just developed or are still developing such systems. Several academic administrators reported that their inventory systems were used to screen purchase orders and avoid duplication, but it was not clear that this application was useful. Only one university we visited, Iowa State, routinely uses an inventory system to facilitate sharing of equipment (see section below on Optimization of Use).

The REAP inventory includes only 3 percent of Iowa State's general inventory. The other university inventory systems we learned about included all equipment capitalized (commonly at $500 or more) and were very expensive to implement. One university, for example, has been working for two years to set up a system at a cost of more than $200,000; the provost estimates a steady state operating cost of $100,000 per year. A second inventory system requires eight full-time employees in steady state and is highly automated, with a bar-code label on all property. When fringe benefits and overhead are added to salaries, the cost is about $350,000 per year, plus computer time. A third institution estimates a cost of about $10,000 per month just to maintain the data base and thinks it would be prohibitively expensive to develop a system useful for facilitating sharing of research equipment.

These inventory systems are compiled by nontechnical people and do not contain the information scientists must have about equipment to assess its utility. Except at Iowa State, all faculty we asked had only negative comments about the use of inventories to promote sharing.

National Laboratory Systems

The two national laboratories we queried have developed effective inventory systems that contain information on the capabilities and current state of repair of equipment. Data are entered by scientifically trained people. Staff scientists can call up the inventories on their computer terminals, and they are useful in promoting sharing of equipment. The labs also have used their inventories to argue for the replacement of old equipment, and managers felt this information was instrumental in persuading Congress to fund the Department of Energy Utilities and Equipment Restoration, Replacement, and Upgrade Program (see the following section on Replacement and Disposition).

Replacement and Disposition of Research Equipment

Replacement of research equipment with state-of-the-art models, and disposition of worn or unneeded equipment, also are significant management problems in universities. Replacement is extremely costly: data from the NSF instrument survey indicate that equipment in use in 1982-1983 has a replacement cost today that is about 50 percent greater than its original acquisition cost. Further, inadequate disposition procedures can hamper optimum use of equipment and entail costs that might be avoided.

Universities, as we have seen, do not plan their purchases of research equipment in the same way that government or industry does. They have no programs like the DOE Utilities and Equipment Restoration, Replacement, and Upgrade Program, which has been funding replacement of poor and inadequate equipment in defense-related national laboratories since 1982. Sandia, Los Alamos, and Lawrence Livermore national laboratories, for example, will receive about $434.9 million through this program, which is projected to end in 1988. Many industrial laboratories also replace scientific equipment systematically. For reasons of obsolescence and taxes, they depreciate equipment on an accelerated basis and often replace it as soon as it has been fully depreciated, even if it is still useful.

Universities face difficulties in orderly replacement and modernization of research equipment. They pay no taxes and so gain no tax advantages by depreciating equipment. They can collect a use allowance (6 2/3 percent per year), or depreciation (at a higher, negotiated rate) over the useful life of the equipment, as an indirect cost of research under OMB Circular A-21, but both faculty and funding agencies are exerting considerable pressure to limit indirect costs. Depreciation or the more common use allowance, moreover, can be collected only for equipment purchased with nonfederal funds and so plays no role in replacing the majority of research equipment, which is purchased with federal grant or contract funds. Furthermore, DHHS auditors interpret OMB Circular A-21 so that universities that convert from use allowance to depreciation part way through the life of equipment must then value it as if they had used the same rate of depreciation, rather than the lower use allowance, since acquiring the equipment. This requirement imposes a significant financial penalty for conversion (see Chapter 1).

Assessing user charges to amortize the replacement of equipment is rarely practical, and recovery of purchase costs is not allowed for equipment bought with government funds. We found no case where equipment purchase costs were fully recovered through user charges. One problem is that the necessary charges may be higher than most grants can support. Recovery of purchase costs is being attempted in one electron microscope facility we know of, where the user charge will be $75 an hour when the debt-service costs are included. Other electron microscopes on the campus, which recover only operating and maintenance costs, charge $35 an hour.

A further bar to systematic replacement and modernization is that investigators' needs can change rapidly as new research opportunities arise. Additionally, when faced with tight budgets, investigators tend to fund people and look for equipment in the next review cycle.

The situation is different for centralized equipment with many users and for service equipment in the university infrastructure that needs to be kept up to date. When the task involves more than the cooperative effort of a few investigators or a department, then some universitywide planning is called for. Still, we found no plans for systematic replacement of such equipment. With the present strained budgets of most universities, the problems are dealt with only when they become crises.

Disposition Issues

Among important issues in disposition is the lack of incentive to transfer equipment between investigators at the same or different universities. Some still-useful equipment is transferred informally within universities by using barter payment. One university, for example, circulates a newsletter advertising equipment that is sought or available for barter payment. Under the present system, however, faculty at most universities have no incentive to transfer equipment other than the need for space (which, like equipment, warrants careful management). Faculty have every incentive to keep equipment in case it might someday be needed again; only at Iowa State, among the schools we visited, was much equipment relinquished. This lack of incentive to transfer is a barrier to optimum use, since the equipment may be more valuable to a laboratory other than the original recipient. Agencies and academic administrators could do more to facilitate transfer of equipment from one researcher to another by means of incentives in the form of savings to the receiver and rewards to the donor.

One might imagine the transfer of useful equipment at bargain prices within or between universities. The main obstacle seems to be that such sales could result in charging the government twice for the same equipment. If allowed, the practice would yield income for activities that support the original sponsor's mission. Formalizing the procedure on a larger scale would encourage more efficient use of many items of research equipment.

Disposal procedures at universities require attention. The administrator of a large academic laboratory reported that procedures for disposing of equipment that is not needed are frequently time consuming and complicated. While questions of title and disposal are being worked out, the lab must store the equipment at a cost of $15 per square foot per year. The administrator felt that the lab's operating funds could be better spent. He cited inadequate administrative support for an efficient disposal system as a significant contributor to the problem. We learned of a case at another university where excessive administrative delay by the surplus property office prevented researchers from realizing a good price on sale of equipment.

Many universities have an administrative entity assigned to dispose of equipment that no one wants. In our investigations, it was seldom praised. The major exception is the REAP organization at Iowa State, which was highly praised for its efforts on disposal and salvage of surplus equipment.

OPTIMIZATION OF USE

Sharing Equipment

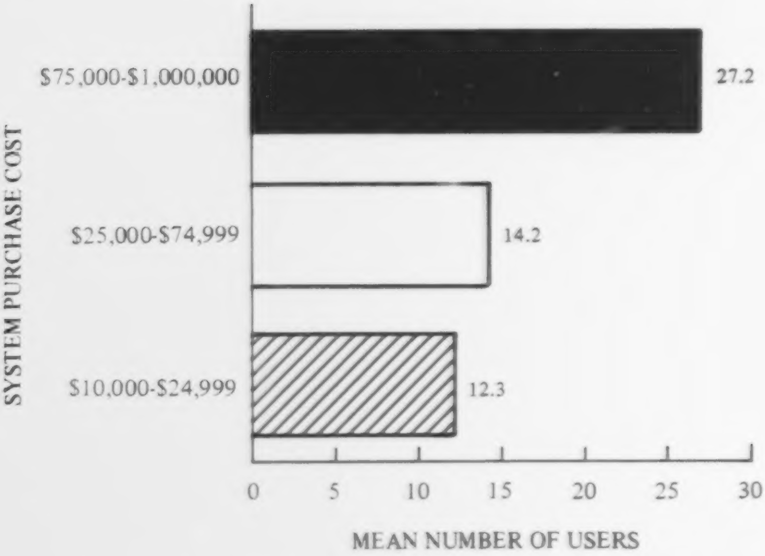
Sharing of research equipment is a straightforward way to ease equipment problems in universities and is commonly practiced. The degree of sharing that is required or is feasible, however, varies greatly among fields of research; important determinants include the cost and nature of the equipment and the characteristics of academic science.

The higher the costs of obtaining and operating a piece of equipment, the higher are the pressures to share it. Thus sharing by many users has long been characteristic of facilities in high-energy and nuclear physics and in optical and radio astronomy. The principle is evident in NSF data on academic facilities in use in 1982-1983. The mean number of users was 27 for equipment costing $75,000 to $1,000,000, 14 for equipment costing $25,000 to $74,999, and 12 for equipment costing $10,000 to $24,999 (Figure 7). The same data show that 60 percent of academic instrument systems costing $75,000 to $1,000,000 were located in shared-access facilities (Figure 8).

The nature of the research and the equipment sometimes works against sharing. The research may require modifications to equipment that make sharing impossible, or it may simply require full-time use of the equipment on one project. When apparatus is contaminated by samples, as occurs in molecular beam epitaxy machines or certain chemical analytical apparatus, for example, sharing is neither practical nor effective.

Further, the characteristics of academic science are not generally conducive to unlimited sharing of resources. While more collaboration as well as more sharing of research equipment would be desirable in some situations, emphasis on individual creativity and scholarship is essential to the vitality of the university. Creative research is frequently a solitary activity, and it often requires dedicated equipment. Professors are judged by their contributions as individuals, which tends to discourage collaborative efforts.

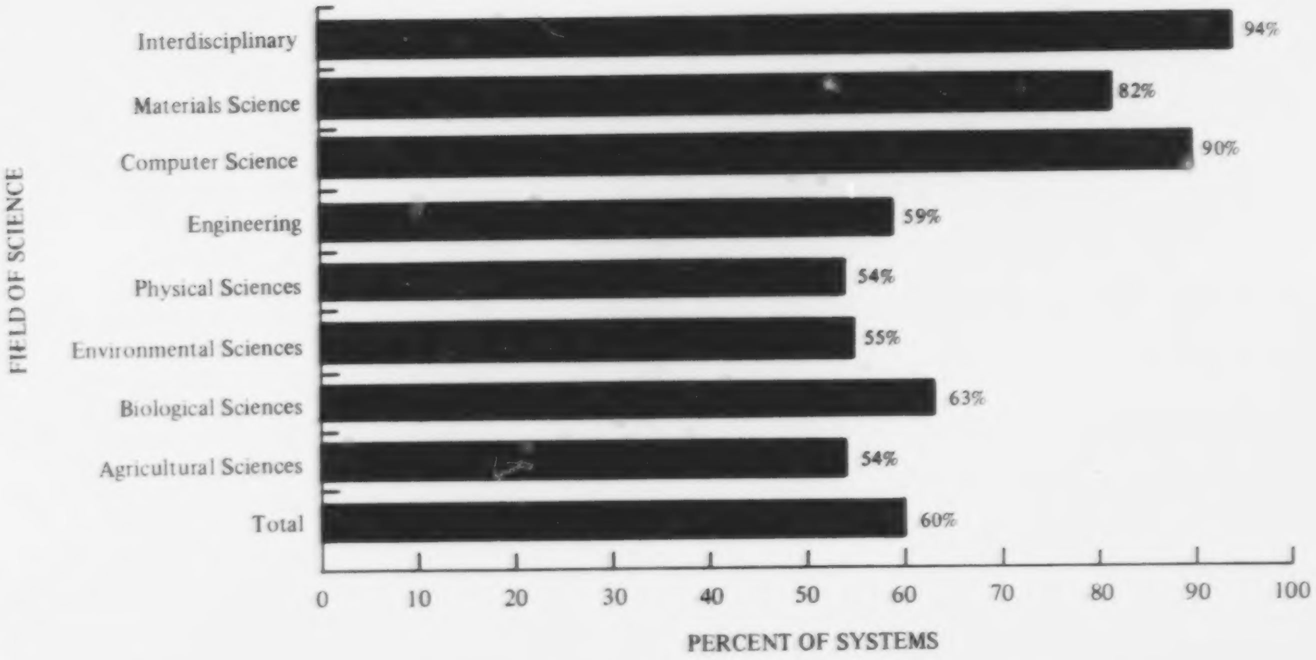
FIGURE 7
Mean Number of Instrument System Users
by Purchase Cost
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

FIGURE 8

Percentage of Academic Research Instrument Systems
Costing $75,000-$1,000,000
Located in Shared-Access Facilities
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

Computers, if powerful enough, are easily shared and sufficiently different from other types of research equipment that we will not consider them here in depth. The increasing power and decreasing cost of small computers act to reduce the number of users who might share a machine, and we feel that computers increasingly will be shared only by those who require the computational power of supercomputers. Methods of giving universities access to supercomputers have been addressed by the NSF Advisory Committee on Advanced Scientific Computing Resources.[3] NSF has since announced plans to fund supercomputer research centers at four universities (see Chapter 1).

We found substantial sharing of research equipment at all of the universities visited in the course of this study. The methods of sharing ranged from informal lending and borrowing of smaller, inexpensive items to operating larger items as centralized facilities.

Small pieces of equipment are frequently shared within a geographical radius determined by their portability and knowledge of their existence. Informal interaction among faculty and graduate students is the most common mechanism. It should be noted that sharing usually offers educational benefits. Students learn to use a wider variety of equipment to solve their problems and in the process have the opportunity to exchange ideas with a wider circle of people.

Sharing is very effective when the research requires limited and routine use of commercially available service-type equipment such as electron microscopes, surface analytical equipment (Auger electron or x-ray photoemission spectroscopy), and high-field nuclear magnetic resonance spectrometers. (These items cost between $100,000 and $1,000,000.) Sharing such equipment also often permits a technician to be provided to maintain and operate the equipment as well as to train students to use it.

The utility of centralized facilities is illustrated by the 14 Materials Research Laboratories currently supported by NSF through block grants to major research universities. We visited four of these labs. The grants support multi-investigator research on materials as well as central facilities incorporating the kinds of equipment noted above. We found that the Materials Research Laboratories have been effective at operating central facilities on a relatively large scale and providing an excellent educational environment for students.

In many academic departments, especially chemistry departments, centralized equipment, such as infrared, visible, and ultraviolet, NMR, EPR, and mass spectrometers, is used intermittently by a large number of researchers. Departmental laboratories at a medical school we visited were set up so that centrifuges were conveniently located for use by several research groups; we found this type of sharing in most universities.

We observed that shared instrument facilities work best when supervised by a faculty member whose research depends on them and who will insist on high-quality, up-to-date performance from the equipment. Service and repair costs increase when equipment is shared by many scientists, and a technician is usually necessary to operate it and train users; in larger centralized facilities one technician can often look after several related pieces of apparatus.

Faculty generally wish to share equipment with their colleagues, but want sufficient control to ensure that the equipment remains in optimum working order. Under these conditions, investigators often share equipment, but commonly by means of collaboration with another investigator on a problem both are pursuing.

We learned that officials at some universities encourage sharing by giving higher priority to allocation of funds for shared equipment than for nonshared equipment. We found a similar practice in industry, where equipment is frequently shared. Laboratory management at a large chemical company we visited encourages sharing by rewarding, in its research budget, a group that finds it can avoid buying equipment by sharing with another group.

The REAP Program

As noted earlier, an inventory system plays a significant role in equipment sharing at only one school we visited, Iowa State University. The university established its research equipment assistance program (REAP) in 1974 with the help of an NSF grant of $114,000. Its direct costs currently total about $123,000 per year, including salaries, computer support, and other expenses. REAP has evolved into an accepted, trusted, and helpful program in support of researchers' needs for equipment. Its components are an easily accessible, simplified, edited inventory; a diagnostic service to help maintain equipment in good working order at low cost; an apparatus stockroom that recycles, loans, and salvages equipment; and a staff who are devoted, helpful, and interested, but remain low key and nonobtrusive. A detailed report on the program appears as Appendix G, and only a brief summary will be given here.

The computerized inventory is focused on scientific instrumentation and includes only 3 percent of the university's general inventory; in June 1984, it contained almost 10,000 items (each costing at least $500 initially) having a total value of nearly $30 million. The inventory is used widely as a sharing tool; faculty are encouraged to use it to learn if a piece of equipment on campus might fit their needs. The REAP staff stands between the holder and the seeker of the apparatus, and the holder is not coerced into sharing. If the device is heavily scheduled, fragile, time consuming to use, or modified so that it is not useful to others, a "no" from the investigator is accepted without challenge. The general response, however, is an offer to share, because REAP is liked by the researchers, actively helps the faculty, and guarantees that borrowed equipment will be returned in at least as good condition as when it was loaned.

REAP maintains a storeroom of unused equipment and parts, and browsing is encouraged. The staff are knowledgeable troubleshooters and often can either repair equipment or point to the repairs necessary to avoid expensive service contracts. They are regularly sent to courses on equipment servicing to help them keep up to date.

As universities develop inventory systems, we believe that they might usefully consider the innovations found in REAP. It is clear that REAP owes much of its success to a devoted and technically competent staff, a well-designed, specialized inventory, and an academic community that takes pride in finding cost-effective solutions to problems. When a university has limited access to external repair facilities, is small enough to have institutionwide cohesiveness, and is able to attract and retain an interested and competent staff, an investment in a program like REAP seems wise.

National, Regional, and Industrial Facilities

Academic scientists also share research equipment at national and regional facilities funded by federal agencies (see Chapter 1). To a considerably lesser extent, they have access to industrial equipment.

National Facilities

National facilities involve equipment that is far too expensive--in the range of tens to hundreds of millions of dollars--to be provided exclusively to a single university. These facilities are usually associated with and managed by a university or national laboratory. Two that we visited were the Meson Physics Facility (LAMPF) operated by Los Alamos National Laboratory and the Stanford Synchrotron Radiation Laboratory (SSRL). Both are supported by DOE.

The chief management problem at national facilities is to provide access and a suitable environment for exploratory research. Beam time at SSRL, for example, is oversubscribed; time is assigned to investigators only after their requests are subjected to rigorous review, and only about half of the worthy proposals are awarded beam time. This limited beam time tends to reduce opportunities for serendipitous discovery and high-risk research. In an attempt to overcome this problem, SSRL has recently adopted the Participating Research Team (PRT) mode. A small number of consortia (with university participation in combination with industrial or government labs) set up instrumentation (which the consortium must pay for) on one of the SSRL ports; the university part of the PRT has one-third of the beam time to use as it wishes, the industry-government part has one-third, and the remaining third is allocated to the larger user community through the review process.

Regional Facilities

Regional facilities are designed to serve a smaller, local community of users. They are funded by agencies that include NSF, NIH, NASA, and DOE. While the equipment at these facilities is expensive, it would not be out of the question to buy it solely for one of the larger universities.

These facilities provide regional service with varying degrees of effectiveness.[4] Our observations suggest that when problems occur, they have two fundamental causes. First, the scientists running the facility are usually more interested in doing research than in providing service to users. Second, even given strenuous efforts to be fair, scientists at the host institution have the advantage of being there; thus a large community of local users may dominate the facility. Where a large and scientifically strong group of potential users is based at one institution, it may be better to provide a facility dedicated to that institution, instead of to regional services. In many cases, however, regional facilities have served their communities well by providing access to equipment for users who otherwise would not have such an opportunity.

The laser "lending library" (operated by scientists at the University of California-Berkeley and Stanford University) is a regional facility praised by all users. The library places a laser in an investigator's lab for a few months without charge; the sponsoring agency (NSF) pays the maintenance costs and has found them to be considerable. The regional laser facility at MIT is more conventional; the lasers are housed there and users come to them. It, too, has provided lasers to scientists who would not otherwise have had access to them. Neither of these facilities, however, is useful to investigators whose work requires long and nearly continuous access to a laser.

Industrial Facilities

Academic scientists can best gain access to state-of-the-art equipment in industrial laboratories through collaboration with industrial investigators. Such collaboration does occur frequently in pursuit of common interests, and we encountered several examples. Normally, however, industrial labs are not set up to service outside users; barriers to academic use include considerations of safety and liability and proprietary information, as well as conflicting work schedules. Industry does provide equipment for academe in other ways, sometimes involving state governments, and these mechanisms are covered in Chapters 2 and 5.

Remote Access to Research Equipment

Because research equipment increasingly is operated under computer control, it may be possible to share it by means of remote access. Such access might also reduce the time and expense of travel to some regional or national facilities. In the future, high data-rate transmission (at 52 Kbaud, for example) from the instrument to the user via satellite down-link will be inexpensive, as will high-resolution computer graphics. User-to-instrument communication at 1,200 baud now exists, is comparatively cheap, and should be adequate for issuing most commands. (Computing equipment--generally excluded from this discussion of sharing--is widely used by remote access.)

One case that we encountered suggests the potential of remote access. Some students and a professor in the chemistry department at Duke University set up a link between a small microcomputer, their obsolete departmental nuclear magnetic resonance (NMR) spectrometer, and a modern NMR at Research Triangle Park, 15 miles away. A user at Duke was able to operate the remote instrument as if seated at its console. This experimental study began in 1981 and employs specially designed software. We think the idea might be applicable to a limited number of other instruments in situations where the investigator need not have intimate contact with samples after they are prepared and they could be delivered by messenger. As computer networking grows and universities upgrade their telephone systems and install optical fiber communications links, opportunities for remote access to equipment, even on individual campuses, might expand significantly.

Remote control of telescopes is now a fact at large observatories; and communications technology can extend the link between telescope and control room from tens of feet to thousands of miles.[5] Kitt Peak National Observatory, for example, is now scheduling remote observations. Within the limitations imposed by the relatively slow telephone data rate (one acquisition TV frame every 30 seconds, and one terminal graphics display every 10 seconds), the observing runs thus far have proved quite successful.

STRATEGIC PLANNING

The costs and complexities of acquiring and managing first-rate academic research equipment are some of the several pressures, mainly financial, that appear to be moving universities toward campuswide strategic planning.[6,7] Such planning in part leads to preferential allocation of resources to disciplines that offer the university the best opportunities to achieve distinction. A university might allocate minimal resources to some departments, or even close them, for example, in order to provide better research facilities for others. We believe that more hard decisions of this kind will have to be made, but keeping in mind that universities work on a much longer time scale than most of our society. Sound strategic planning must involve faculty participation, but clearly requires more centralized decision making than is now common in academe.

RECOMMENDATIONS

The universities' ability to acquire and manage research equipment efficiently reflects factors that include individual circumstances, decentralized authority, the project-grant system that funds much of the equipment, and state and federal regulations. Within this context, however, we have identified a number of management practices that are effective and warrant more widespread use. These practices form the basis of the recommendations that follow.

The recommendations on the whole imply a need for universities individually to consider a more centralized approach than is now the general practice in their management of research equipment. We note that other developments, mainly the result of financial pressures, point in the same direction. They include the universities' growing interest in debt financing and in developmental efforts involving close cooperation with state governments and industry. Such activities generally call for centralized decision making in the universities. More broadly, universities are displaying growing interest in strategic planning, which clearly depends on more centralized decision making.

We recommend...

1. **That universities more systematically plan their allocation of resources to favor research and equipment in areas that offer the best opportunities to achieve distinction.** Such strategic planning should involve participation by both administrators and faculty. The process may well call for hard decisions, but we believe that they must be made to optimize the use of available funds.

2. **That universities budget realistically for the costs of operating and maintaining research equipment.** These costs impose serious and pervasive problems, and failure to plan adequately for full costs when buying equipment is widespread as well. Full costs include not only operation and maintenance, but space renovation, service contracts, technical support, and the like. Maintenance is particularly troublesome. Hourly user charges are commonly assessed to cover the salaries of support personnel and the costs of maintenance, but are difficult to set optimally and are rarely adequate.

3. **That [illegible] and administrators at universities seek agency approval to spread the cost of expensive equipment charged directly to research-project awards over several award years.** As noted in Recommendation 3 under the Federal Government, individual research grants and contracts cannot normally accommodate costly equipment, and this problem would be eased by spreading costs over several years.

4. **That universities act to minimize delays and other problems resulting from procurement procedures associated with the acquisition of research equipment.** To be most effective, the procurement process should be adapted to the specialized nature of research equipment, as opposed to more generic products. Similarly, specialized purchasing entities or individuals would facilitate timely acquisition of equipment at optimum cost. Also beneficial would be formal programs designed to inform purchasing personnel and investigators of the needs and problems of each.

5. **That universities consider establishing inventory systems that facilitate sharing.** One such system is the basis of the research equipment assistance program (REAP) at Iowa State University. The REAP inventory includes only research equipment. REAP may not be cost effective for all universities, but most should find elements of it useful.

6. **That universities use depreciation rather than a use allowance to generate funds for replacing equipment, providing**

that they can negotiate realistic depreciation schedules and dedicate the funds recovered to equipment. Universities can use either method, but rates of depreciation are potentially higher--and so recover costs more rapidly--than the use allowance (6 2/3 percent per year) because they can be based on the useful life of the equipment. Both methods, however, add to indirect costs, and neither can be used for equipment purchased with federal funds.

7. **That universities seek better ways to facilitate the transfer of research equipment from investigators or laboratories that no longer need it to those that could use it.** Faculty at most schools have no incentive to transfer equipment, excepting the need for space, and every incentive to keep it in case it might be needed again. Some systematic mechanism for keeping faculty well informed of needs and availability of equipment would be useful.

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4

Debt Financing

INTRODUCTION

Tax-exempt debt financing has long been used by universities to fund large capital expenditures and in recent years has attracted much attention as a means of funding research equipment. The methods of debt financing employed range from long-term instruments, such as revenue bonds, to short-term leases. Regardless of the method, debt financing of research equipment must compete with the university's other needs for debt. Universities frequently use the proceeds of long-term, low-interest bonds to finance projects such as new buildings, new telephone systems, and major remodeling. When the buildings include laboratories, most of the associated fixed equipment and some movable scientific apparatus are purchased with the proceeds of the issue. In the 1950s and 1960s much scientific apparatus came with new buildings at expanding universities, but recent years have seen little net expansion.

Concern About Payment

The amount of research equipment obtained by debt financing varies widely among universities, but the central computing facility at most schools we visited was either leased or financed by borrowed funds. Universities normally use debt financing to obtain equipment for a research project only if funds are not available from other sources. The basic concern is the availability of income to cover payments on the debt.

Some universities indicated that multi-investigator and block grants are valuable in providing a stable income stream for equipment acquired through debt financing. User fees and grant or contract support, however, are the most common sources of income for payments on equipment debt or leases. Many universities are concerned that these sources are unpredictable and unreliable and that they are likely to have to subsidize debt-service costs. We learned of no central computing facility that was leased or financed by borrowed funds, for example, that had enough income to cover the total costs of the lease or debt; all required a subsidy from the school's general funds. Institutions are additionally concerned that recovery of such subsidies (i.e., the annual deficit in a specialized service center) can be very difficult to negotiate as an element of indirect cost reimbursement under OMB Circular A-21.

Because of limited opportunity to develop a reliable income stream to retire debt, some universities use no debt financing for research equipment. Some state universities are forbidden by state law to incur debt. Other universities are very active in debt financing, but generally require a fallback source of income, such as college or departmental resources, to pay the principal and interest on a debt if necessary. To obtain financing, backup commitments from departmental or college operating budgets or from a university-affiliated foundation are usually necessary.

Administrators at many universities with debt financing available appear to be very selective in its use and to restrict it to large purchases (more than $250,000) for which a repayment process can be developed. One university we visited has formal guidelines for use of a line of credit for research equipment costing more than $50,000. At others, the faculty had not been told that debt financing was a potential means of acquiring equipment. At one major university we visited, senior academic officers were unaware that a line of credit had been obtained by a senior finance officer, partially to finance research equipment.

IMPLICATIONS AND ANALYSIS IN DEBT FINANCING

An important aspect of borrowing money to buy academic research equipment is that, like assumption of debt for any purpose, it shifts the locus of responsibility and decision making. U.S. universities are decentralized in any event, and the heavy reliance on individual, competitive research grants and contracts ordinarily confers considerable authority on principal investigators. Borrowing to buy research equipment, however, imposes risk on the university as a whole and so requires a shift from decentralized to centralized planning and decision making by the school's administration. Such shifts can contribute to greater use of strategic planning by universities (see Chapter 3).

Analytical Requirements

Sound borrowing decisions demand a painstaking analysis of costs, risks, and potential impact. A thorough assessment of needs is essential. One university research foundation reported assuming a multimillion dollar debt to acquire a supercomputer without securing positive commitments from projected users. Plans to repay the debt through user charges were based on estimates and verbal assurances from potential commercial users that did not materialize. The institution was left with a very large debt and insufficient revenue from user charges to repay it.

The parameters of a needs assessment will vary. The university may wish, for example, to focus on particular types of equipment, on replacing obsolete items, or on enabling faculty to establish new programs of research. Universities also have canvassed potential external users, such as faculty at nearby institutions and government and corporate scientists, when equipment was suitable for sharing.

A problem reported repeatedly by universities was failure to plan for full costs when buying equipment. Full costs include shipping, space renovation, operation and maintenance, service contracts, technical support, insurance, utilities, and the like. As a general rule, full costs should always be included in equipment budgets and should be included, at least selectively, in calculations of how much to borrow, recognizing where appropriate the possible use of other funds to pay these costs.

The analysis also should cover projected sources of repayment, with the stress on known sources and reasonable expectations. If user charges are expected to supply revenue for repayment, for example, one cannot assume that they can be assessed at 100 percent of acquisition and interest costs without making the equipment too expensive for potential users. It may also be wise to assess as accurately as possible the allowability of interest costs under OMB Circular A-21, which requires prior agency approval to charge interest to federal grants or contracts. One university reported that its line of credit was approved for conformity with OMB Circular A-21 by five federal agencies. In the one equipment purchase thus far under this financing plan, one of the agencies declined to allow interest charges, even though the money was available in the grant through rebudgeting. The interest is being paid from private gift funds.

Prospective borrowing for equipment is best examined in terms of the university's total debt structure. This examination focuses especially on sources and amounts of revenue projected to repay all debts, repayment schedules, and overall levels of university liability. This analysis requires the university to forecast how it will meet its combined obligations and determine whether its projections are reasonable. It is important to develop at least an outline of a contingency plan for repaying equipment debt in case projected sources of repayment funds do not materialize.

Impact on Academic Programs

Evaluation of using debt for instrumentation should include the impact on the university's capacity to sustain research and instruction, focusing particularly on the future. Too much debt restricts the ability to respond to new challenges and opportunities in research and education. Some debt, judiciously designed to fit the circumstances of the university, may be very useful. In universities where faculty and administrators were satisfied with the decision to borrow, we found that debt was viewed as a supplement to other funds employed to sustain or expand existing programs and help to initiate new ones.

The Limit of Debt

We have no formula to determine how much debt a university can sustain. The appropriate level depends on many variables, including the school's philosophical approach to financial management. The National Association of College and University Business Officers says of a particular ratio of debt service to revenue, "No national standards for budget percentage dedicated to debt service may be inferred from the median values. The willingness and ability to commit revenues to debt service vary greatly among institutions."[1]

Among factors that have been identified[2] as measures of the debt capacity of a university are:

- Ratio of available assets to general liabilities (ordinarily stipulated at 2:1 minimum).
- Ratio of debt service to unrestricted current fund revenues.
- Ratio of student matriculants to completed applications.
- Ratio of opening fall full-time enrollment this year to opening fall full-time enrollment in base year.

A number of factors in addition to these ratios usually are considered in assessing the debt capacity, or creditworthiness, of universities.[3]

CHOOSING THE APPROPRIATE DEBT INSTRUMENT

A number of forms of debt financing are available to universities, and each debt instrument has terms and conditions that can be attractive in the right circumstances. Examples of the use of debt financing by universities are described in Appendix H, and representative debt instruments are summarized in Appendix I. It should be noted that the types of instruments available, the relevant tax laws and interpretations of them, and the conditions of the debt market are always subject to change.* Thus the selection of debt instruments by universities should be based on current expert advice from investment, legal, and tax counsel. The discussion of debt instruments in this chapter is intended to be illustrative, not comprehensive.

Factors to be considered in selecting a debt instrument include the amount to be borrowed and the equipment to be bought. One supercomputer, for example, may call for a different debt instrument than many devices each costing less than $100,000. The urgency of the need may be a factor--a line of credit may be arranged fairly quickly, while a bond issue is time consuming. The single most important factor in selecting a debt instrument is the correlation with use: short-term debt for short-term use, long-term debt for long-term use. Also a factor is the impact of different repayment schedules on the university's programs. In addition, different types of debt instruments have different costs, including the rate of interest, issuance costs, legal fees, and printing charges.

SHORT- TO MEDIUM-TERM DEBT INSTRUMENTS

Short- to medium-term debt instruments include leases, municipal leases, lines or letters of credit, pooled revenue bonds, tax-exempt variable rate demand bonds, and tax-exempt commercial paper. Maturities vary from 1 to 10 years. Selection criteria may include the following:

- Equipment is needed only for a specific period and may or may not have to be permanently retained by the university.
- Leasing costs can be identified with a specific piece of equipment, which can be readily identified with a grant or contract for reimbursement.

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*The material in this chapter was current as of October 1984.

- A lease can be arranged to include a maintenance and service contract.
- Short-term debt can be used temporarily until permanent funding becomes available.
- Conditions in the bond market do not favor issuance of long-term debt.
- The institution may not have the credit rating or sufficient funding needs to issue long-term debt.

The Decision to Lease or Purchase

The decision to lease or purchase usually involves a present-value analysis, in which the financing alternatives' net cash flows over time are discounted back to present-day value (see Table 6). The financing alternative with the lowest present-value cost would be considered best on a cost basis. The final decision to lease or buy depends on the prospective lessee's total financial position and equipment need. The ease and the initial low cost of entering into a lease agreement should not preclude performing cost-benefit analyses of other debt alternatives. Over the long term, high-priced, long-term equipment will most likely have a higher net effective cost under a lease arrangement than under a long-term debt instrument. For short-term, low-priced equipment, the university might consider a line of credit as an alternative to leasing.

General Uses of Leasing

Ordinary leasing takes two basic forms:

- Operating lease: an institution acquires the use of equipment for a fraction of its useful life. Title is retained by the lessor, and the lease contains no option to purchase the equipment. The lessor may provide services in connection with maintenance and insurance of property.
- Capital lease: a capital lease must meet one of the following criteria:
    - Title is transferred to lessee at the end of the lease.
    - Lease contains a bargain purchase option.
    - Lease term is at least 75 percent of the leased property's estimated economic life.
    - Present value of the minimum lease payments is equal to 90 percent or more of the leased property's fair market value, less related investment tax credit retained by the lessor.

TABLE 6 Present Value Analysis

Yr.	Outflow($)	Inflow($)	Net($)	PV Factor*	Net Present Value($)
Option A					
0	1,000,000	0	(1,000,000)	1.000	(1,000,000)
1	100,000	500,000	400,000	0.909	363,600
2	100,000	500,000	400,000	0.826	330,400
3	100,000	500,000	400,000	0.751	300,400
4	100,000	500,000	400,000	0.683	273,200
5	100,000	500,000	400,000	0.621	248,400
Net present value					516,000
Option B					
0	0	0	0	1.000	0
1	400,000	500,000	100,000	0.909	90,900
2	400,000	500,000	100,000	0.826	82,600
3	400,000	500,000	100,000	0.751	75,100
4	400,000	500,000	100,000	0.683	68,300
5	400,000	500,000	100,000	0.621	62,100
Net present value					379,000

DECISION: Option A, purchasing equipment with available cash.

Option A states that the acquisition of new laboratory equipment will save the department $500,000 per year in contracting the services from a private lab. Costs of about $100,000 per year are directly attributable to the new equipment maintenance which will reduce the potential annual savings to $400,000. The cost of the equipment and its installation is $1.0 million. At the end of five years, the equipment has zero salvage value. Option B states that the leasing of new laboratory equipment will save the department the same $500,000 as in Option A. The cost of lease will be $300,000 per year for five years with an additional $100,000 per year for maintenance. The department has no purchase option at the end of the lease.

*PV factor assuming a 10 percent discount rate.

SOURCE: Coopers & Lybrand.

The benefits commonly attributed to leasing are primarily available in a tax-oriented lease in which the lessor retains and claims the tax benefit of ownership. This type of lease is called a true lease for tax purposes. Nearly all operating leases are considered true leases, but only some capital leases qualify as true leases.

Not-for-profit organizations do not accrue tax benefits from leasing capital equipment, benefits that are available to profit-making organizations. With state universities, IRS regulations prevent the lessor from benefiting from the investment tax credit because the end property user is a government entity. Leases can be structured, however, to pass on the tax benefits of ownership to the lessor. These methods include a sale-leaseback and third-party lessor, which may be an affiliated foundation (see Chapter 5). Such methods require careful review and professional counsel to ensure that the transaction is structured to meet IRS regulations and other federal requirements.

State universities have structured leases as a sale-leaseback transaction in which the equipment is sold by the university to purchaser/lessor and then leased back by the university. These arrangements are considered operating leases, allowing the purchaser/lessor to receive the tax benefits. In most cases, however, the sale-leaseback is not the best method relative to other forms of tax-exempt financing available to state universities (e.g., bank line of credit).

Private universities, for major projects that include both buildings and equipment, can combine debt financing with leases. This arrangement allows the university to match the economic life of the asset with a comparable financing period. However, the institution should consider tax-exempt financing (e.g., a line of credit or industrial revenue bond) for major funding needs or for aggregate university funding, because tax-exempt financing could be a cheaper form of debt than leasing equipment on an individual basis.

Foundations established as separate, incorporated entities can provide additional financing flexibility to state universities. Such foundations can offer a number of benefits by incurring debt and arranging leasing on behalf of a university. An example is the Georgia Tech Research Corporation mentioned in Chapter 3. A state institution and the foundation will have an arm's-length relationship that can provide needed financing while complying with various state regulations.

Municipal Leases

Municipal leases require the lessee to be a state, city, or government entity, and so do not apply to private universities.

For tax and legal purposes, the municipal lease is considered a conditional sales contract. Municipal leases usually include the following provisions:

- The university receives title to the equipment for a nominal fee at the end of the lease term.
- No down payment is required from the university.
- The university makes clearly defined payments of principal and interest.
- The lessor receives none of the tax benefits of ownership, but can treat the interest portion of the lease payments as tax-exempt income.
- The lease term is generally on a fiscal year-to-year basis with renewable options; the university's liability is limited to the actual lease term (excluding renewable options), so it can cancel the lease at the end of each year.

Through a municipal lease, a state university can enter into a lease-purchase agreement and still meet state constitutional or statutory constraints on multiyear debt. The cost of the lease usually ranges from 70 to 90 percent of the prime interest rate; the high cost reflects the lessor's risk that the lease can be cancelled on a year-to-year basis. Interest, however, is the only expense associated with the lease. Also, the ability to cancel on a year-to-year basis provides some insurance against technological obsolescence.

Municipal leases generally are used to acquire equipment costing in the range of $100,000 to $1 million. They are also useful for acquiring lower priced equipment: they can be arranged quickly and normally are used to acquire small pieces of equipment that depreciate quickly and have questionable salvage value.

Mechanics

In arranging a municipal lease, the university selects the equipment and deals directly with the vendor on the sale terms and price. When the terms are settled, the university negotiates the lease with a third-party lessor. Municipal leases usually include a fiscal funding clause to protect the lessee from any claims the lessor may have against cancellation of the lease. The clause makes the lease conditional on full appropriation of funds to pay the lease in the next fiscal year. If the lease includes such a clause, the lessor may require a nonsubstitution clause to protect against the lessee's cancelling the initial lease on the basis of nonappropriations and then leasing similar equipment from another lessor.

Third-Party Lessors

An affiliated nonprofit organization or foundation could enter into a municipal lease arrangement for a state university. The foundation would act as a third-party lessor and could provide:

- Additional financial security to back the leasing arrangement.
- Review of department heads' and principal investigators' municipal-lease requests to ensure that revenue sources are available to cover lease commitments.
- Management of the leased equipment.
- Support for collecting and paying lease payments.

Additionally, the foundation would not be subject to fiscal appropriations and would be able to plan for the funding of long-term lease contracts.

Line of Credit

A university that anticipates a near-future need for borrowed funds but does not know its specific requirements can negotiate with a bank for a line of credit. The line of credit represents an assurance by the bank that funds will be made available to the university as needed, based on the terms and conditions of the initial agreement and barring any major changes in the financial position of the university. Once a line of credit is negotiated, the university can request funds from the bank. The bank reviews the request(s) and extends the loans up to the stated limit of the line of credit. Lines of credit usually are extended for one to five years and for ceilings of $2 million to $15 million on outstanding loans.

A line of credit gives the university a standby source of funds that can be obtained without having to renegotiate terms and conditions each time a loan is needed. By paying a fee on the unused portion of the funds, the university can arrange a letter of credit or a standby loan guarantee from the bank to ensure the funds' availability.

Mechanics

A university with an established credit rating can most likely negotiate with a number of banks before arranging a line of credit with one of them. Depending on its financial strength, the university may be able to arrange more than one line of credit. The general terms of a line of credit specify:

- Interest rate will average 60 to 75 percent of the prime interest rate because the line of credit is considered a tax-exempt debt.
- Loan ceiling represents the total amount of credit that the bank will extend to the university under the line of credit.
- Put and call provisions state the period in which the bank can request repayment in full of all outstanding loans and the period in which the university can prepay its loan.
- Fee represents the bank's compensation for extending the line of credit; it can be expressed as a stated amount or as a percentage of the unused line of credit.
- Conditions define specific terms of the line of credit, e.g., the bank may ask the university to maintain compensating bank balances, depending on the underlying credit of the university and the bank's loan pricing structure.
- Security defines the collateral the bank requires to support the loan (e.g., the university's pledge of unrestricted endowment funds or a lien on the purchased equipment).

Procedures for Use

Once a bank line of credit is obtained, the university should establish procedures for using it. The line of credit could be drawn upon, for example, to meet loan requests from department heads and principal investigators. Each request would have to be documented to justify the loan and demonstrate a source of revenue to repay it. Internal administrative controls would have to be established to review and process requests and ensure that the use of the line of credit conforms to budgetary and research priorities. If numerous small loans were made, additional administrative control would be required to monitor loan limits and debt service.

Pooled Revenue Bond

A pooled revenue bond is issued under a designated government authority to meet the aggregate funding requirements of a group of state or private institutions. Bond pools are of two types: a blind pool does not identify the participating universities or the projects to be funded; a composite pool identifies both.

To ensure the marketability of the bond issue, the authority will most likely purchase an insurance policy that guarantees repayment in the event of default by any of the participating universities. The authority may require a participating university that does not have an established credit rating to obtain a letter of credit to guarantee its loan or to pledge cash and securities as collateral. Financially strong universities that can issue their own debt may not gain cost advantages from participating in the pool. The participation of universities with established credit ratings, however, is important to ensure that the pooled revenue bond gets a favorable rating and can be marketed to investors.

The pooled revenue bond meets the minimum requirements ($5 million to $10 million) for a marketable, cost-effective issue, and the costs of issuance are shared by the participating institutions. It works well when the participants need similar types of equipment: investors are looking for some element of commonality--such as the useful life of equipment--so that they can better assess their risks. The mechanism permits a university to finance equipment purchases that would not warrant issuance of a revenue bond on its own.

Mechanics

After the bonds are issued, the authority enters into a loan agreement with each participating institution. The agreement specifies the term and amount of the loan, the repayment schedule, and the interest rate. The periods of the participating institutions' loans generally range from three to ten years, but no loan can extend past the maturity date of the bond issue. IRS regulations give the authority three years to disburse the proceeds of the bond. Within that period, the authority may invest the proceeds at a higher rate than the tax-exempt rate of the bonds to reduce the borrowing costs to the participants.

Tax-Exempt Variable Rate Demand Bond

Tax-exempt variable rate demand bonds (VRDBs) carry a floating interest rate set periodically in one of three ways:

- Percentage of prime interest rate.
- Percentage of 90-day U.S. Treasury Bill rate or bond equivalent basis.
- Indexed to tax-exempt notes.

The VRDB, nominally issued with a 25 to 30 year maturity, gives the university access to long-term debt at short-term rates. When issuing long-term debt is not feasible or is relatively expensive, VRDBs permit the university to begin construction of buildings or procure equipment without funding delays; they permit the issuance of permanent debt to be postponed until conditions in the long-term bond market improve. The short-term feature of the VRDB can offer quite favorable interest rates, which may range three or more percentage points below fixed long-term bond rates. VRDBs entail risks if the university plans eventually to convert them to long-term debt. One such risk is the uncertainty in the regulatory environment, which may restrict the university's ability to issue long-term debt. One of the many varieties of variable rate demand bonds is the adjustable rate option bond described in Example G, Appendix H.

Mechanics

VRDBs are issued for the university by a designated state or local authority. The bonds are sold to short-term investors, normally tax-exempt money market funds that can only hold securities with maturities of 90 days or less. The terms generally give the investor the option of returning the bonds to the issuer after giving a seven-day notice and give the issuer the option of recalling the bonds from the investors upon a 30-day notice. (The adjustable rate option bond in the example allows only annual returns of the bonds for payment.) Because the investor can return the bonds, the university must demonstrate its ability to pay for them. If the bonds can be immediately resold, the university can readily repay the investor. If new investors cannot be found, however, the university needs some way to raise the necessary capital. The most common way is a bank letter of credit.

Through a letter of credit agreement, the bank lends the university the necessary funds at a specified rate of interest and with a set repayment schedule. Borrowing under the terms of the letter of credit can be costly, in that the interest rate is higher than the university is paying on the VRDBs. Most universities will have to use it, however, because the institution may have insufficient cash reserves to ensure repayment of the VRDBs. With the letter of credit the bank may provide other services, including placement of the initial bond offering and assistance in locating new investors if initial investors return the VRDBs. (In many cases, investment bankers provide the marketing and remarketing service.) The university and its bank negotiate the terms of the letter of credit, which generally costs from 1 to 1.5 percent of the amount of the issue and has a five-year term with cancellation and renewal clauses.

Tax-Exempt Commercial Paper

Tax-exempt commercial paper (TECP) consists of a program or series of short-term obligations with maturities of 270 days or less, issued by a designated authority for a pool of universities. TECP gives universities the flexibility and liquidity of short-term borrowing at the lower interest rates offered on tax-exempt securities. Issuance costs are shared by the participants. Additionally, the TECP is designed to be rolled over at maturity without delays and added issuance cost, so the university is not locked into long-term debt and can repay the loan at any time without penalty.

Mechanics

The designated authority would issue the tax-exempt commercial paper and provide the funds to participating institutions that request loans to finance the construction or renovation of buildings and the acquisition of equipment. The issued amount of the TECP would reflect the aggregate amount of the participating institutions' loan requests over the period of the program, say, two or three years. The relatively high cost of setting up a tax-exempt commercial paper program makes it necessary to aggregate fairly large pools of money. The minimum for the pool commonly is $50 million.

The TECP would be a limited obligation of the authority and would represent no obligation of the authorizing state or county. The financial backing for the issue is the revenues and pledged funds of the participating universities. Before a loan is made, the authority must approve the creditworthiness of the participating institutions. An institution that does not have an established credit rating could obtain a letter of credit or pledge assets as collateral. The authority would make a long-term loan to the institution for a period not greater than the expected life of the debt program, which could be as long as 10 years.

The university would repay its loan in equal monthly installments that would reflect repayment of principal and the costs of interest, administration, and issuance. The interest on the loan would be determined monthly and reflect the average interest rates of TECPs sold during the month. Repayment of the TECP is based solely on participating institutions' loan payments to the authority.

LONG-TERM DEBT INSTRUMENTS

Long-term financing commits a university to 10 to 30 years of debt. Tax-exempt revenue bonds and general obligation bonds are the major forms of long-term financing. Certificates of participation, industrial development bonds, and "on behalf of..." debt instruments are specific forms of revenue bonds.

Types of Tax-Exempt Bonds

For state, local, and other municipal government entities and authorities, municipal bonds are a major means of financing the construction and maintenance of public facilities. Municipal bonds are cost effective because the interest paid to the bond holders is exempt from federal income tax and sometimes from state or local income tax. The tax-exempt status permits issuers of municipal bonds to pay lower interest rates than are paid on corporate bonds.

Municipal bonds are differentiated by the type of funds that secure payment. The bonds are of two general types:

- General obligation bonds are secured by the taxing power of the state or local government. All sources of the specified government unit's revenues will be used to pay off the debt, unless specifically excluded. The bonds are backed by the "full faith and credit" of the state or local government.
- Revenue bonds are issued to finance a specific revenue-generating project. They are secured by the project's revenue and are not backed by the "full faith and credit" of a state or local government.

Long-term debt financing for universities generally involves revenue bonds or industrial development bonds. The industrial development bond is issued by a state, local, or other designated government entity to finance the construction or purchase of plant facilities or equipment to be leased and used by a private entity. The bond is backed by the credit of the private entity and not by the issuing government entity.

Revenue bonds do not burden the credit capacity of the municipality nor require a referendum, as do most general obligation bonds. The state or local government issues the revenue bonds or empowers an authority, commission, special district, or other unit to issue the bonds and construct and operate or lease the specified building/equipment.

Revenue and industrial development bonds can be used by both state and private institutions. The tax-exempt bond can be issued as long as it fulfills a "public purpose" under state law in accordance with Internal Revenue Code Section 103. State universities enjoy tax-exempt status because they are considered subdivisions of the state. A private university, however, must use a tax-exempt conduit such as a county, industrial development authority, educational facilities authority, or similar agency. Revenue bonds issued by both state and private universities are backed by the creditworthiness of the institution. If it does not have sufficient collateral to attract investors, the issue would most likely have to be underwritten by an insurance company to ensure its marketability. Other forms of credit enhancement are available. The university might obtain a letter of credit, for example, or, where feasible, set aside a portion of endowments as collateral. Such credit enhancements have the effect of lowering the interest rate that must be paid to attract investors.

Mechanics

The tax-exempt bond is a legal promise by the backer--municipality, political subdivision, designated public authority, state university, or private university--to pay the investor a specified amount of money on a specified date and to pay interest at the stated period and rate. A bond issuance basically involves four main parties or groups of individuals:

- The institution--in this case a state or private university, responsible for paying principal and interest from its own revenues.
- The issuer--a governmental entity or designated authority that borrows money through sale of tax-exempt bonds.
- The dealers--securities firms or commercial banks that underwrite, trade, and sell securities.
- The investors--tax-exempt bond funds, banks, casualty insurers, and individuals.

The minimum feasible amount of a bond issue is normally $3 million because of the sizable costs of bringing the issue to market. These costs would include legal, accounting, and brokerage fees as well as incidental costs such as printing. Individual bonds have a minimum face value of $5,000, but on average are issued in $25,000 denominations.

Legal and tax counsel are essential to ensure that all reporting, tax, and disclosure requirements are met. Municipal security issues do not have to follow the reporting requirements of the Securities and Exchange Commission (SEC), but the Municipal Securities Rulemaking Board, an independent, self-regulatory organization of dealers, banks, and brokers, has established guidelines for the municipal securities industry. A potential issue would be governed by the antifraud provisions of the Securities Acts and SEC Rule 10b-5. Additionally, a tax-exempt bond must adhere to Internal Revenue Code Section 103, which defines the types of facilities that can be financed with tax-exempt bonds.

Certificates of Participation

Certificates of participation (CPs) are a relatively new debt instrument that resulted from the need of public institutions to lease high-priced facilities. This form of financing provides access to the equivalent of long-term debt, but does not constitute direct indebtedness. The legal structure of CPs is basically the same as for a lease-purchase agreement. CPs, however, allow a university to lease costly facilities and equipment with several investors acting as the lessor. CPs represent a share in a lease--the certificate holder has an interest in the lease proportional to the percentage of the investment. The underwriting for CPs is complex and lengthy; the efforts and cost are comparable to those of issuing a revenue bond. CP investors will require some form of security from the university to ensure that funds are available to meet lease payments. In some cases, the university may have to purchase a letter of credit or establish a debt reserve fund to cover one year's debt service. The cost of placement requires that the CPs be issued for at least $1 million.

"On Behalf of..." Financing

"On behalf of ..." financing is arranged by a third-party guarantor for a state or private institution. The financing could take the form of either a revenue bond or a lease. Generally, "on behalf of ..." financing is used for special equipment. A tax-exempt foundation (third-party guarantor) issues a revenue bond on behalf of the university to purchase the equipment. When the equipment is acquired, the foundation leases it to the university. The university makes lease payments to the foundation and receives title to the property at the end of the lease. Although the foundation is the guarantor of the "on behalf of ..." issue, the bond or lease represents an indirect obligation of the institution. "On behalf of ..." investors look to the university's revenue-generating capability and creditworthiness to evaluate the riskiness of the issue.

An advantage of "on behalf of ..." financing is that the debt does not appear on the university's balance sheet. The financial impact on the university is reflected as a contingent liability for future lease payments. The leasing arrangement between the foundation and the university is on a year-to-year basis with annual renewal options. A state university would use "on behalf of ..." financing only when revenue bonds could not be issued. Some state governments have legislative authority over the state university's ability to issue revenue bonds and can restrict the purpose of the bond and the use of the funds. "On behalf of ..." financing would be easier to issue than revenue bonds in these states, but the cost of issuance is higher.

INNOVATIVE TECHNIQUES

A number of innovative financing techniques have been used for state and private universities. One of these is to structure the bond issue so that the institution's alumni may be investors, not just contributors. The bonds are issued and purchased by alumni. The proceeds are placed in an irrevocable charitable remainder trust from which interest payments are made to the bond holders. The alumni can claim the principal of the bond as a charitable donation for tax purposes and also can treat the interest as tax-exempt income. When the bonds mature, the trust is retired and the principal goes to the university. The financial advantage to the university is a substantial reduction in debt service. The major disadvantage of this type of financing is that the institution does not have use of the funds until the bonds are retired; for this reason, the bonds should be issued with short-term maturity.

Grantor Trust

A mechanism proposed recently by an investment banking firm involves a lease pool large enough to spread financing costs over many leases with consequent economies of scale. The goal is to finance acquisition of equipment from research awards over three to seven years while avoiding the problems associated with pooling funds from different award periods and possibly from different awards.

The proposal envisions a grantor trust created to acquire tax-exempt lease obligations of participating universities. (The specific proposal involves a nonprofit corporation of some 55 universities--the Universities Space Research Association--formed originally for other purposes.) The trust would offer investors certificates of participation that provide tax-exempt income and return of capital in three to seven years. An initial offering on the order of $20 million is contemplated. Additionally, corporate guarantees would be sought to cover up to 25 percent of the pool in case of defaults or failure to exercise annual lease-renewal options. Advances made by corporations under these guarantees would be structured as tax-deductible contributions. The guarantees would be designed primarily to make the certificates of participation more attractive to investors, and the grantor trust would not anticipate involving them.

RECOMMENDATIONS

Universities traditionally have used tax-exempt debt financing to spread payments for costly facilities over periods of years and lately have been using the method to some extent to buy research equipment. A number of financing methods can be adapted to the special characteristics of equipment, such as its relatively short technologically useful life. A noteworthy aspect of debt financing is its imposition of risk on the university as a whole, which requires a shift from decentralized toward centralized authority.

We recommend...

1. **That universities explore greater use of debt financing as a means of acquiring research equipment, but with careful regard for the long-term consequences.** Universities vary widely in their use of debt financing, but a universal concern is the need for a reliable stream of income to make the debt payments. It should also be recognized that the necessary commitment of institutional resources, regardless of the purpose of the debt financing, erodes the university's control of its future, in part by reducing the flexibility to pursue promising new opportunities as they arise. Debt financing also increases the overall cost of research equipment to both universities and sponsors of research.

2. **That universities that have not done so develop expertise on leasing and debt financing of equipment.** This expertise should include the ability to determine and communicate the true costs of debt financing and should be readily accessible to research administrators and principal investigators. The increasing complexity of tax-exempt debt financing, the many participants, the necessary legal opinions, and the various political and/or corporate entities associated with debt financing make it essential that universities fully understand the marketplace.

REFERENCES

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2. Peat, Marwick, Mitchell & Co., *Ratio Analysis in Higher Education* (Washington, D.C., 1982).
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5

Private Support of Academic Research Equipment

INTRODUCTION

Higher education in this country has long enjoyed significant support from private sources, including individuals, foundations, and business and industry. Universities increasingly have been seeking such support, and it has risen steadily in recent years. Private assistance to academe takes various forms, and in some measure is helping to address the need for research equipment.

An increase in private support for academic research equipment was one of the aims of the federal Economic Recovery Tax Act (ERTA) of 1981 (PL 97-34). The act resulted from concern over the nation's industrial strength and was designed in part to spur research and development, both academic and industrial. It permits special charitable deductions for scientific equipment contributed by its manufacturers to colleges and universities. It also provides tax credits for industrial spending on R&D conducted both in-house and by other performers, including universities. The act took effect in August 1981, and, unless extended, certain provisions will expire December 31, 1985.

Extent of Private Support

Data on trends in funding of academic research equipment do not exist. Data are available, however, from the NSF National Survey of Academic Research Instruments on major instrumentation systems in use in 1982-1983. The data show that industry funded 4 percent of the aggregate acquisition cost of such systems and that individuals and nonprofit organizations funded 5 percent (Table 3, Chapter 2). The NSF data show also that about 2 percent of the instrumentation systems in use in 1982-1983 were donated, as opposed to being purchased by the universities (Table 7).

TABLE 7 Means of Acquisition of Academic Research Instrument Systems in Use in 1982-1983, by Field (Number and Percent of In-Use Systems)

	Total	Purchased New	Locally Built	Purchased Used	Donated New	Donated Used	Govt. Surplus	Other
Total, Selected Fields	36,351	32,409	942	1,342	410	317	409	522
	100%	89%	3%	4%	1%	1%	1%	1%
Agricultural Sciences	1,650	1,575	17	39	4	2	5	9
	100%	95%	1%	2%	-	-	-	1%
Biological Sciences, Total	15,043	14,138	71	475	22	36	43	259
	100%	94%	-	3%	-	-	-	2%
Graduate Schools	6,358	5,959	40	234	4	13	10	98
	100%	94%	1%	4%	-	-	-	2%
Medical Schools	8,685	8,179	31	241	17	24	32	162
	100%	94%	-	3%	-	-	-	2%
Environmental Sciences	2,122	1,756	98	103	26	31	88	19
	100%	83%	5%	5%	1%	1%	4%	1%
Physical Sciences	8,770	7,502	366	428	20	98	196	161
	100%	86%	4%	5%	-	1%	2%	2%
Engineering	6,786	5,613	379	209	309	126	78	72
	100%	83%	6%	3%	5%	2%	1%	1%
Computer Science	876	766	0	56	30	23	0	0
	100%	87%	-	6%	3%	3%	-	-
Materials Science	650	619	7	22	0	0	0	2
	100%	95%	1%	3%	-	-	-	-
Interdisciplinary, not elsewhere classified	454	440	4	10	0	0	0	0
	100%	97%	1%	2%	-	-	-	-

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic Research Instruments and Instrumentation Needs.

Trends in funding of R&D presumably apply grossly to the funding of the associated equipment. For example, in 1983 industry funded about 5 percent of academic R&D. Industrial funding of academic R&D, in constant dollars, grew at an average annual rate of 6.7 percent during 1967-1983 (Appendix A). The comparable growth rate for federal funding was 1.6 percent. Federal funding of academic R&D in 1983, however, totaled $4.96 billion (current dollars), or 64 percent of total funding and more than 13 times the industrial contribution. A drop of 1 percent in the federal support of university research would require a 20 percent increase in industry support to make up for it.[1]

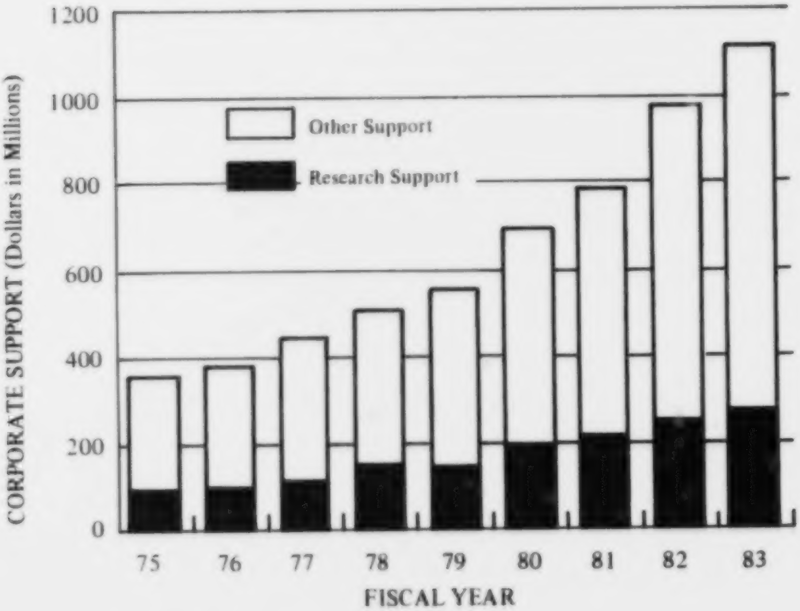
In addition to the foregoing NSF data is information on corporate support of academe compiled by the Council for Financial Aid to Education (CFAE). The two sets of data partly overlap and so cannot be combined to give totals. In any event, the CFAE data show that voluntary private support of higher education, from all sources, more than tripled during 1966-1983, to $5.15 billion. Corporate support has been rising faster than other private funding and in 1983 comprised 21.4 percent of the total. Corporate support also is more than twice as likely to be earmarked for research as are contributions from other private sources; corporate giving so earmarked in 1983 was 25 percent of the total, or $274 million (Figure 9). The most dramatic change in corporate giving between 1980 and 1982, CFAE's most recent survey years, was in departmental and research grants, which almost doubled.[2] Gifts of equipment accounted for much of the gain. CFAE believes that ERTA contributed significantly to corporate giving of equipment.

MECHANISMS OF CORPORATE SUPPORT

Companies support acquisition of academic research equipment by a variety of means in addition to donations of equipment itself. These mechanisms include cash gifts, contract research, discounts on equipment, industrial affiliate programs, research centers and consortia, and informal loans and sharing.

Donations of equipment have been particularly common in computing, microelectronics, and engineering, but less so in other areas. Equipment offered for donation, however, may not be state of the art, particularly in industries where the technology is advancing rapidly. Also common are offers of instrumentation that does not meet the research needs of the proposed recipient. Further, donations of equipment generally do not provide for the costs of renovating space and installing, operating, and maintaining the equipment. These costs have prevented some universities from accepting donations. In Chapter 3 we cited the university

FIGURE 9
National Estimates of Corporate Voluntary
Support of Colleges and Universities
Fiscal Years 1975-1983



SOURCE: Council for Financial Aid to Education.

visited by the study team that declined a gift of computer-aided design equipment because it could not afford the $170,000 per year required to operate it.

Cash gifts support a variety of research and instructional needs, including research equipment. Some companies have set up organizations to plan corporate philanthropy, including matching of employees' contributions to colleges and universities. Companies sometimes help to support the research of a particular investigator or program. Unrestricted cash gifts often are applied wholly or partly to the costs of acquiring and using instrumentation and sometimes are used to meet federal matching requirements for buying equipment.

Companies generally fund contract research at universities on a project-by-project basis, much as federal agencies support contract research. Academic investigators and administrators, however, report significant differences in the handling of industrial and federal research contracts. Negotiations with industry are not hampered by the problems associated with federal regulations identified in Chapter 1. Corporate negotiators, moreover, recognize that state-of-the-art equipment and the costs of operating and maintaining it are part of the price of effective research. Contracts with industry, therefore, are more likely to cover all of these costs than are federal contracts.

Companies frequently use discounts and flexible payment schedules, often free of interest, to help universities obtain research equipment. These mechanisms in the aggregate can provide substantial benefits to universities. One company visited by the study team used a two-for-one discount on purchase of new equipment to generate goodwill and to institute a series of informal exchanges between its scientists and investigators at the recipient school.

Industrial Affiliates

Industrial affiliate programs (also called industrial liaison programs) provide substantial support for departments and programs at a number of universities. The companies involved pay annual membership fees that vary with the arrangement, but often are in the range of $30,000 to $50,000 per company. The university in turn generally provides seminars conducted by faculty, preprints of publications, copies of theses and dissertations, and informal contact with faculty and students. Some programs also provide a limited amount of consulting by faculty at no charge. These industrial affiliate arrangements can provide considerable discretionary funding, which could be used to purchase research equipment.

An elaboration of the industrial affiliate concept is the research center or consortium. These arrangements may be organized to pursue mission-oriented research. Centers for research on very large-scale integration of electronics, for example, are being established at MIT and Stanford. The corporate members of the Stanford center initially contributed $750,000 each. Of the $20 million thus raised, more than $4 million was used to acquire state-of-the-art instrumentation. Annual corporate dues are $100,000 per company and are expected to comprise one-sixth of the center's sponsored research budget, with the remainder to come from federal agencies. The privileges of membership include limited rights to certain aspects of the technology developed in the center's research programs.

A somewhat different approach is the Houston Area Research Center (HARC). It was formed in 1982 by four universities--Rice, Texas A&M, Houston, and Texas-Austin--to conduct research that none of them could handle easily alone. HARC received private funding initially, and now has begun to receive federal contract funding. Projects under way in 1984 included raising funds for a supercomputer for the four schools and surrounding industry, development of geological testing techniques and large-scale geological surveys and studies, and support for activities in high-energy physics.

Another vehicle of corporate support is a nonprofit corporation, supported by contributions from companies, which funds contract research at universities. The arm's-length sponsored research agreements negotiated can provide significant funding for research equipment. One example of such an arrangement is the Center for Biotechnology Research, in San Francisco, California. It is supported by six companies and administered by a three-member board of trustees.

Academic investigators occasionally benefit from informal loans or sharing of company-owned equipment. Most often such arrangements result from personal contacts between scientists.

Freedom of Inquiry

A critical issue in academic-corporate relationships is preservation of the academic freedom that contributes so much to the strength of research in our universities. The proprietary interests of a corporate sponsor of research, for example, are inherently in conflict with the academic practice of open and rapid dissemination of research results. Means of managing academic-industrial relationships have been examined increasingly in recent years as such arrangements have proliferated.[3,4] The general issue is beyond the scope of this report, but certainly must be considered in arrangements to secure corporate funding of academic research equipment.

OTHER PRIVATE SUPPORT

The NSF data cited earlier indicate that private individuals, not-for-profit organizations, and foundations fund academic research equipment at a level comparable to corporate support. Philanthropic programs generally support instrumentation through research grants and general program support. Universities have raised matching funds for research equipment from individual private donors and philanthropic organizations. The added leverage of matching funds, plus the appeal of current sophisticated technology, help scientific research to compete with efforts to raise funds for other activities, such as athletic programs and hospitals. Universities report that fund drives for specific items of research equipment have proved effective.

Individuals also may help to fund academic research equipment by investing in bonds issued to raise money for universities (see Chapter 4) or in research and development limited partnerships (see below).

TAX INCENTIVES

Corporate and other private entities traditionally have been allowed tax deductions for donations of cash and property to colleges and universities. ERTA, however, in response to the need for research equipment in academe, attached permanent special tax benefits to donations of such equipment by its manufacturers. Also, in accord with its basic goal of spurring technology, ERTA created additional tax credits for industrial investment in research and development, including academic R&D. (Unless extended, the R&D tax credit will expire December 31, 1985.) Further, most of the states in recent years have adopted tax incentives identical or similar to the federal provisions relating to contributions of scientific equipment. In addition to these federal and state provisions, tax benefits are available to research and development limited partnerships, which might provide some support for academic research programs.

Contributions of Scientific Equipment

A company that donates equipment to a charitable (tax-exempt) organization generally is allowed a tax deduction equal to the cost of the equipment to the company (production cost). ERTA increased the deduction to production cost plus half of the difference between cost and fair market value (normal selling price) for equipment donated to institutions of higher education, subject to certain provisos, among them:

- The donor must be the manufacturer of the equipment. The cost of parts from outside suppliers may not exceed 50 percent of the donor's cost in the equipment.
- The equipment must have been manufactured no more than two years before donation, and the university must be the original user.
- At least 80 percent of the use of the equipment must be for research or research training in the physical or biological sciences. Direct education of students in these fields is excluded, and the social and behavioral sciences are excluded altogether.
- The equipment must be used in the United States, and the university may not transfer it to others for money, other property, or services. The university must verify in writing that it will meet all use and disposition requirements.
- The deduction is limited to twice the production cost of the equipment. If the cost of the equipment to the manufacturer is $100, for example, the tax deduction is limited to $200, regardless of the normal selling price of the equipment.

In addition to increasing the deduction for such contributions, ERTA raised the limit for corporate charitable deductions from 5 percent to 10 percent of taxable income. Although many corporate donors do not reach even the 5 percent limit, some do, and the higher limit on deductions clearly could affect the level of corporate contributions of equipment to academe.

The incentive provided by ERTA for donating qualified equipment to colleges and universities can be assessed on two bases: the direct cost of donation (production cost less tax benefit) and the total cost of donation (production cost, plus net income foregone by donating rather than selling, less tax benefit).[5] These relationships are shown in Table 8, using a production cost of $100 and selling prices of $100, $300, and $400. Note that the tax deduction under ERTA plateaus at a selling price of $200 (twice the production cost). At that point, ERTA confers its maximum reduction, about 28 percent, in total cost of donation. Net income foregone, however, continues to rise, so that, at a selling price of $400, ERTA reduces the total cost of donation by about 21 percent. Even so, it would appear that ERTA offers a significant incentive to donate qualified equipment to academe. If the data of Table 8 are raised to more realistic levels--say, a production cost of $100,000 and a selling price of $300,000--the direct

TABLE 8 Effect of ERTA on Cost of Donating Equipment (in Dollars)

	ERTA/non-ERTA		
Production cost	100/100	100/100	100/100
Selling price	100/100	300/300	400/400
Tax deduction	100/100	200/100	200/100
Tax benefit (at 46 percent tax rate)	46/46	92/46	92/46
Direct cost of donating (cost less benefit)	54/54	8/54	8/54
Net income foregone (price less cost less tax on gross profit)	0/0	108/108	162/162
Total cost of donating (cost plus net income foregone)	54/54	116/162	170/216

SOURCE: Eileen L. Collins, An Early Assessment of Three R&D Tax Incentives Provided by the Economic Recovery Tax Act of 1981 (Washington, D.C.: National Science Foundation, April 1983).

cost of donating becomes $8,000 under ERTA and $54,000 without ERTA. Similarly, the total cost of donating becomes $116,000 under ERTA and $162,000 without ERTA.

Bargain Sales

A company that wishes to provide qualified research equipment to a university but is unwilling to donate it outright may still obtain tax benefits under ERTA by means of a bargain sale. A bargain sale is a sale for less than fair market value, often entailing a larger than normal discount. The university gets the equipment at a good price; the donor receives a tax deduction for a charitable contribution, but also must recognize gain on the transaction to the extent that the sales price exceeds the cost basis apportioned to the sale. The calculation is illustrated in Table 9. The university pays $750 for equipment that lists at $1,500. The company receives a $250 after-tax profit under the bargain sale provisions of ERTA, or 85 percent more than the $135 it would have received without ERTA. It should be noted also that the charitable deduction under ERTA is limited to twice the cost basis of the equipment.

Company Considerations

Companies' decisions on how best to provide research equipment to academe on a charitable basis depend on both tax and nontax considerations. The two are necessarily intertwined, but nontax benefits are the primary impetus for giving.

Makers of scientific equipment depend very much on academe as a market for their products and as a source of the technically trained manpower and research results essential to their businesses. They provide equipment on a charitable basis, therefore, to sustain the quality of teaching and research, to familiarize prospective users and employees with their products, to obtain feedback on the performance of their equipment and on needs for new products, and to maintain relations with faculty.

Although tax benefits are not the primary motivator, they do appear to affect the contribution of equipment to universities. A company may prefer, for example, to sell costly, high-profit equipment to a university at a substantial discount, rather than donating it, so as to ease the economic penalty of the contribution.[6] This approach has been used both before and after ERTA, but ERTA clearly could affect the decision to sell or donate. Tax benefits also appear to affect the size of contributions, once the decision to contribute has been made.

TABLE 9 Calculation of Gain and Charitable Deduction in Bargain Sale

List price = $1500
Cost basis = 500
Bargain sale price = 750

Basis for sale = cost basis + (bargain sale price/list price)
$500 x ($750/$1500) = $250

Basis in gift = cost basis - basis for sale
$500 - $250 = $250

Company's gain = bargain sale price - basis for sale
$750 - $250 = $500

Charitable deduction = Basis in gift plus half of the gain foregone by selling at less than list price
$250 + ($750 - $250)/2 = $500

	ERTA	Pre-ERTA
Gain on sale	$500	$500
Charitable deduction	- 500	- 250
Taxable income	0	250
Cash received	750	750
Tax	0	- 115
Total benefit	750	635
Equipment cost	- 500	- 500
Net benefit to company	$ 250	$ 135

SOURCE: Coopers & Lybrand.

Some academic opinion holds that company officials who decide whether and how to contribute equipment are not fully abreast of the available tax benefits, even though company tax specialists are well informed. In this respect, for example, it appears that the bargain sale provisions of ERTA have been largely ignored.

Research and Development Tax Credit

ERTA created a 25 percent tax credit for incremental spending by industry on "research and experimentation," both in-house and under contract. The contract research, however, is restricted to work related to the taxpayer's trade or business, or basic research in colleges and universities. The credit is available for expenses incurred after June 30, 1981, and before January 1, 1986, unless new legislation is passed to extend the credit or make it permanent.* Money spent on scientific equipment under research contracts in academe qualifies for the credit.

As with the ERTA deduction for equipment donations, the research must be conducted in the United States and is restricted to the physical and biological sciences. Money for basic research may be paid either to the contracting universities or to a fund that awards grants for academic research. The requirements of the law preclude tax credits for research costs incurred by new ventures before they actually engage in business.

The 25 percent tax credit is computed on qualified research costs in excess of a floating average of research costs paid or incurred during the prior three years. In-house research costs are fully qualified, but only 65 percent of contract research costs is qualified. The three-year floating average of research costs cannot be less than 50 percent of current-year research costs. Thus the maximum tax credit is 12.5 percent of qualified, current-year research costs and 8.1 percent if only contract research costs are incurred. The calculation is illustrated in Table 10.

Company/University Considerations

The R&D tax credit reduces a company's costs for contract research at a university. Further, the costs qualified for in-house

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*The President's Tax Proposal of May 1985 would extend the credit for three years.

TABLE 10 Calculation of R&D Tax Credit

Qualified research expenses, 1985		
In-house		$640,000
Contract, nonbasic ($200,000 x 0.65)		$130,000
Contract, basic ($200,000 x 0.65)		$130,000
Total		$900,000
Less base-period research expenses		
1982	$ 600,000	
1983	$ 500,000	
1984	$ 700,000	
Total	$1,800,000	
Average	$ 600,000	(600,000)
Excess qualified expenses		$300,000
Rate		0.25
1985 Tax credit		$ 75,000

SOURCE: Coopers & Lybrand.

research include only wages and supplies, while the full costs of contract research are qualified. On the other hand, the tax credit is based on 100 percent of qualified costs for in-house research and only 65 percent of costs for contract research. Also, contract work at universities is restricted to basic research, which generally is a long-term effort, whereas corporate interests tend to be short term. The university and the company are both potential beneficiaries of patents arising from the research.

Additional considerations are involved but, on balance, the R&D tax credit does not appear to provide a special incentive for companies to contract for research at universities, as opposed to the qualified alternatives available. Exceptions would include companies that are committed to supporting basic research in academe, but might support more of it in light of the R&D tax credit.

STATE TAX INCENTIVES

Most states in recent years have adopted tax provisions designed to stimulate research at colleges and universities. The state incentives include adoption of the federal deduction for company contributions of scientific equipment to colleges or universities, enactment of provisions comparable to the federal deduction, allowance of the federal deduction and an additional state deduction, and enactment of a credit against tax for contributions of scientific property.

Adoption of the Federal Deduction

The federal deduction for contributions of scientific property to colleges and universities has been adopted by 34 states:

Arizona
Arkansas
Colorado
Connecticut
Delaware
Florida
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Missouri
Montana
Nebraska
New Hampshire
New Jersey
New Mexico
New York
North Dakota
Oklahoma
Oregon
Pennsylvania
Rhode Island

Kentucky
Maine
Maryland
Massachusetts
Michigan
Tennessee
Utah
Vermont
Virginia
West Virginia

Adoption of Deduction Other than Federal

California has adopted a provision essentially identical to the federal deduction for donations of scientific equipment to academe. As under the federal law, a corporation can deduct its basis in the contributed property plus half of the unrealized appreciation with a limit of twice its basis in the property.

Montana allows the federal deduction or a deduction equal to the fair market value of the property contributed, but not greater than 30 percent of the corporate taxpayer's net income.

In New Hampshire, a business that contributes scientific property may deduct, in lieu of the federal deduction, its basis in the contributed property plus 50 percent of the unrealized appreciation, or twice the basis of the property, whichever is less.

Massachusetts allows the federal deduction plus 25 percent of that deduction.

Adoption of Credits

Seven states, including some that have adopted the federal deduction for contributions of scientific equipment, in addition provide various types of tax credits. Idaho, Indiana, and North Dakota allow corporations a credit against tax as a means of stimulating contributions of scientific equipment to colleges and universities within the state. Louisiana allows corporations to elect a credit in lieu of a charitable deduction. Iowa, Wisconsin, and Minnesota allow a credit for increased research expenditures.

In determining expenditures that qualify for research credits, Iowa, Minnesota, and Wisconsin follow the federal definition of "qualified research expenses." The Iowa credit, which is effective for years beginning on or after January 1, 1985, is 6.5 percent of qualifying expenses incurred for research conducted within the state. If the credit exceeds the corporation's tax liability, Iowa refunds the excess with interest unless the corporation elects to apply the credit to its liability for the following year. The Minnesota credit is 12.5 percent of the first $2 million (and 6.5 percent of additional expenses) of the excess of qualified expenses over base-period expenses incurred for research conducted within the state. The Wisconsin credit is 5 percent of the corporation's qualified expenses incurred by research conducted within the state. Wisconsin also provides a 5 percent credit for the purchase of research equipment or construction of facilities to house it.

Idaho allows a credit of 50 percent of the aggregate amount of charitable contributions to institutions of higher education within the state during the year, but not exceeding 10 percent of the corporation's total Idaho tax liability or $500, whichever is less. Indiana also allows a credit of 50 percent of the aggregate amount of contributions during the year to institutions of higher education within the state, but not exceeding the corporation's tax liability minus all other credits, or 10 percent of the corporation's total adjusted gross income, or $1,000, whichever is less.

North Dakota allows a credit of 50 percent of charitable contributions to nonprofit private institutions of higher education within the state or to the North Dakota independent college fund, but not exceeding 20 percent of the corporation's income tax, or $2,500, whichever is less.

Louisiana allows corporations to elect a credit, in lieu of a deduction, for contributions of computer equipment to educational institutions within the state. The credit is 40 percent of the equipment's value or the corporation's total tax liability, whichever is less.

R&D LIMITED PARTNERSHIPS

Research and development limited partnerships are a source of risk capital that may permit individual investors to support academic research programs while sheltering some of their own income.[7] Investors can take current deductions for qualifying research expenditures; subject to certain conditions, they can pay tax at capital gains rates rather than ordinary income rates on royalties or on the sale of patent rights or patentable property.

An R&D limited partnership may include a partner (which could be a university) that contributes ideas or potential products, while other partners contribute capital to finance the necessary research and development. The university need not become a partner, but could license or assign inventions or know-how to the partnership for lump-sum cash payments or royalties. The partnership could contract with the university to perform research whether or not the university had previously provided anything to the partnership.

The partners would share the income from the sale or licensing of products or patents developed. Royalties or capital gains received by the university would not be unrelated business income, nor would fees paid to the university for research performed.

R&D limited partnerships in which the university is a partner potentially have several disadvantages:

- Much university research is more basic than is required for a partnership making high-risk investments in the hope of commercial return.
- The law in this area is still unsettled in many respects, including issues of potential liability.
- A limited partnership offering is a securities offering governed by federal and state law and regulations. Legal fees, brokerage commissions, and general partners' fees are substantial.
- R&D credits provided by ERTA for contract research are not available to a partnership unless it is engaged in a trade or business, intends to use the products developed in that trade or business, and does not intend to transfer the products for license or royalty payments. To be considered engaged in a trade or business, the partnership must be soliciting customers to purchase a product or service, but most partnerships do not solicit customers until after they have developed a product or service.

R&D limited partnerships have not been widely embraced by the academic community, although they have attracted a good deal of interest. The study team encountered no instances of universities' having procured scientific equipment through R&D limited partnerships.

LEASING

For-profit entities that lease equipment to colleges and universities may be able to take advantage of the accelerated depreciation (ACRS) provisions introduced by ERTA to shelter from taxes a part of their income from leasing. (See Chapter 4 for detailed discussion of leasing.) Investment tax credits are not available, however, to for-profit entities that lease to colleges and universities, which is a strong disincentive for such arrangements.

The Tax Reform Act of 1984 reduced the accelerated depreciation benefits previously available to lessors by increasing the number of years for depreciating equipment leased to colleges and universities and by providing that the equipment be depreciated using the straight-line method. The act excludes leasing arrangements for specific types of equipment from the new constraints. Certain high-technology equipment--including computers and peripheral equipment, sophisticated telephone station equipment installed on campus, and advanced medical equipment--can be depreciated by the lessor using normal ACRS rules if the lease period is five years or less. If the lease period is more than five years, depreciation is on a straight-line basis over five years.

DEVELOPING A DONATION STRATEGY

Donation transactions examined during this study (Appendix J) suggest a number of actions that could help colleges and universities to obtain donations of scientific equipment. In particular, it appears that involvement of academic representatives (e.g., development office people, department heads, and principal investigators) with their counterparts in prospective donor companies is vital to building the relationships needed to obtain regular contributions. In addition, colleges and universities that wish to develop donation strategies might consider the following activities:

- Target the manufacturers of equipment most needed by the institution.
- Prepare a description of the university's plans for using the equipment for presentation to prospective donors. The description should include information such as the research planned and the number and background of students and faculty who will be involved. In this respect, many companies expect to receive a written proposal before donating equipment.
- Prepare a description of the mutual benefits of donating equipment. These benefits include the long-range value of strengthening the research and academic programs of the university. More immediate benefits for prospective donors would include:
    - Research programs that are making scientific advances in which the donor is interested.
    - Introduction of the donor's products to potential buyers.
    - Students as potential employees.
    - Federal and state tax incentives that reduce the total cost of donating equipment.
    - Feedback from students and faculty as a source of product improvement and development.
    - Willingness of academic investigators to permit donors to demonstrate to potential customers the use being made of their equipment and the scientific advances being obtained with it.

RECOMMENDATIONS

The effects of ERTA have been studied extensively almost since its passage, primarily with a view to deciding whether the

R&D tax credit should be extended beyond its statutory expiration date, December 31, 1985, and in what form.[5,8] Although many believe that the tax credit has a positive effect, these studies have not produced clear-cut answers for several reasons: the act has been in effect only since August 1981; its effects are entangled with other economic variables in a complex manner; and the uncertain future of the act may have skewed its effects.

The examination of ERTA also has produced views on the value of the equipment-donation deduction, which is permanent under the act. The Council for Financial Aid to Education, as noted earlier, believes that ERTA has contributed significantly to corporate giving of scientific equipment to academe. Similarly, the National Science Foundation has said that both the R&D tax credit and the deduction for donations of equipment "apparently have helped to stimulate the recent surge of industry support for university science and engineering."[9]

The consensus appears to be that ERTA, suitably modified, should indeed spur technology, in part by fostering support for academic research and scientific equipment. We agree with this view. We believe also that colleges and universities could seek more aggressively to capitalize on available tax benefits, federal and state, in soliciting donations of equipment.

We recommend...

1. **That industry take greater advantage of the tax benefits provided by the Economic Recovery Tax Act (ERTA) of 1981 for companies that donate research equipment to universities and fund academic research.** Universities' experience with industry indicates that company officials may not be fully aware of the benefits available, although company tax specialists generally are well informed.
2. **That universities seek donations of research equipment more aggressively by developing strategies that rely in part on the tax benefits available to donors.** Sound strategies would stress both federal and state tax benefits as well as other important benefits to both donor and recipient.
3. **That Congress modify ERTA so that...**

...equipment qualified for the charitable donation deduction include computer software, equipment maintenance contracts and spare parts, equipment in which the cost of parts not made by the donor exceeds 50 percent of the donor's costs in the equipment, and used equipment that is less than three years old. Computers are properly viewed as computing systems, which are incomplete without software. Maintenance of scientific equipment is costly to the point where universities have declined donations of equipment because they could not afford to maintain it. Makers of sophisticated equipment rely primarily on their technological knowledge, not their ability to make parts. Thus the limit on parts from outside suppliers is unrealistic, provided that the manufacturer is in fact in the business of developing and making scientific equipment.

...the provisions on the R&D tax credit are made permanent, with revision to create an additional incentive for companies to support basic research in universities. Equipment acquired under research contracts qualifies for the credit, but ERTA currently provides the same incentive for companies to contract for research in academe as for research by other qualified organizations.

...the social and behavioral sciences are made qualified fields of academic research in terms of the equipment donation deduction and the R&D tax credit. The social and behavioral sciences contribute to the application and utilization of science and technology, and they rely increasingly on research instrumentation.

...qualified recipients of equipment donations and R&D funding, in terms of ERTA tax credits, include research foundations that are affiliated with universities but remain separate entities. Some state universities have established such foundations to receive and dispose of donated equipment because they cannot dispose of it themselves without legislative consent.

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Appendixes

APPENDIX A: R&D EXPENDITURES AT UNIVERSITIES AND 1953–1983

FY	Total	Fed. Govt.	State/ Local Govts.	Indus- try	Inst. Funds	All Other
Current Dollars in Millions						
1953	255	138	37	19	35	26
1954	290	160	42	22	38	28
1955	312	169	47	25	41	30
1956	372	213	53	29	43	34
1957	410	229	60	34	49	38
1958	456	254	68	39	53	42
1959	526	306	76	39	58	47
1960	646	405	85	40	64	52
1961	763	500	95	40	70	58
1962	904	613	106	40	79	66
1963	1,081	760	118	41	89	73
1964	1,275	917	132	40	103	83
1965	1,474	1,073	143	41	124	93
1966	1,715	1,261	156	42	148	108
1967	1,921	1,409	164	48	181	119
1968	2,149	1,572	172	55	218	132
1969	2,225	1,600	197	60	223	145
1970	2,335	1,647	219	61	243	165
1971	2,500	1,724	255	70	274	177
1972	2,630	1,795	269	74	305	187
1973	2,884	1,985	295	84	318	202
1974	3,023	2,032	307	96	370	218
1975	3,409	2,288	332	113	417	259
1976	3,729	2,512	364	123	446	285
1977	4,067	2,726	374	139	514	314
1978	4,625	3,059	414	170	623	359
1979	5,361	3,595	470	193	730	374
1980	6,060	4,094	494	236	829	409
1981	6,818	4,559	540	288	983	448
1982	7,261	4,749	586	326	1,098	503
1983	7,745	4,960	599	70	1,231	585

COLLEGES BY YEAR AND SOURCE OF FUNDS: FISCAL YEARS

FY	Total	Fed. Govt.	State/ Local Govts.	Industry	Inst. Funds	All Other
Constant Dollars in Millions						
1953	427	231	62	32	59	44
1954	480	265	70	36	63	46
1955	509	276	77	41	67	49
1956	591	338	84	46	68	54
1957	628	351	92	52	75	58
1958	682	380	108	58	79	63
1959	772	449	112	57	85	69
1960	929	582	122	57	92	75
1961	1,084	711	135	57	99	82
1962	1,267	859	149	56	111	92
1963	1,490	1,047	163	57	123	101
1964	1,738	1,250	180	56	140	113
1965	1,967	1,431	191	55	165	124
1966	2,228	1,639	203	55	192	140
1967	2,418	1,774	206	60	228	150
1968	2,611	1,910	209	67	265	160
1969	2,582	1,857	229	70	259	168
1970	2,565	1,809	237	67	267	181
1971	2,615	1,803	267	73	287	185
1972	2,630	1,795	269	74	305	187
1973	2,761	1,900	282	80	304	193
1974	2,698	1,813	274	86	330	195
1975	2,767	1,856	269	92	338	210
1976	2,828	1,905	276	93	338	216
1977	2,889	1,937	266	99	365	223
1978	3,077	2,035	275	113	414	239
1979	3,280	2,199	288	118	447	229
1980	3,412	2,305	278	133	467	230
1981	3,490	2,334	276	147	503	229
1982	3,469	2,269	280	156	525	240
1983	3,559	2,279	275	170	566	269

SOURCE: National Science Foundation, Academic Science/ Engineering: R&D Funds Fiscal Year 1982 (Washington, D.C., 1984); and preliminary data for 1983.

APPENDIX B: CURRENT FUND EXPENDITURES FOR RESEARCH EQUIPMENT AT UNIVERSITIES AND COLLEGES BY SCIENCE/ENGINEERING FIELD AND SOURCE OF FUNDS: FISCAL YEARS 1982 AND 1983

(Dollars in Thousands)

Field	Total		Federally Financed			Nonfederal		
	1982	1983	1982	1983	Percent Change 1982-1983	1982	1983	Percent Change 1982-1983
Total	408,498	435,402	266,738	273,076	2.4	141,760	162,326	14.5
Engineering	65,861	75,171	43,220	48,837	13.0	22,641	26,334	16.3
Aeron. & Astron.	2,284	2,837	1,376	2,100	52.6	908	737	-18.8
Chemical	6,442	6,172	3,821	3,559	-6.9	2,621	2,613	-.3
Civil	5,164	6,086	2,823	3,422	21.2	2,341	2,664	13.8
Electrical	18,454	20,685	14,058	14,516	3.3	4,396	6,169	40.3
Mechanical	7,390	10,008	4,208	6,563	56.0	3,182	3,445	8.3
Other, NEC	26,127	29,383	16,934	18,677	10.3	9,193	10,706	16.5
Physical Sci.	78,126	79,153	62,642	62,137	-.8	15,484	17,016	9.9
Astronomy	5,127	4,243	3,941	3,465	-12.1	1,186	778	-34.4
Chemistry	33,323	32,826	24,927	23,632	-5.2	8,396	9,194	9.5
Physics	33,189	35,673	28,527	29,588	3.7	4,662	6,085	30.5
Other, NEC	6,487	6,411	5,247	5,452	3.9	1,240	959	-22.7
Environ. Sci.	28,321	31,123	18,423	19,643	6.6	9,898	11,480	16.0
Atmospheric	4,536	5,025	3,287	3,617	10.0	1,249	1,408	12.7
Earth Sci.	10,536	11,584	6,314	6,609	4.7	4,222	4,975	17.8

Oceanography	8,879	10,928	6,000	6,837	13.9	2,879	4,091	42.1
Other, NEC	4,370	3,586	2,822	2,580	-8.6	1,548	1,006	-35.0
Math/Comp. Sci.	15,228	18,177	9,832	11,705	19.1	5,396	6,472	19.9
Mathematics	2,556	2,668	1,617	1,476	-8.7	939	1,192	26.9
Comp. Sci.	12,672	15,509	8,215	10,229	24.5	4,457	5,280	18.5
Life Sciences	199,574	206,587	120,189	117,342	-2.4	79,385	89,245	12.4
Agric. Sci.	38,921	38,813	11,706	10,746	-8.2	27,215	28,067	3.1
Biol. Sci.	75,889	75,155	53,183	51,041	-4.0	22,706	24,114	6.2
Medical Sci.	78,809	85,942	51,547	51,546	.0	27,262	34,396	26.2
Other, NEC	5,955	6,677	3,753	4,009	6.8	2,202	2,668	21.2
Psychology	5,784	6,526	4,219	4,753	12.7	1,565	1,773	13.3
Social Sci.	7,143	8,938	2,907	2,912	.2	4,236	6,026	42.3
Economics	1,704	1,911	674	728	8.0	1,030	1,183	14.9
Polit. Sci.	765	767	312	319	2.2	453	448	-1.1
Sociology	2,056	1,462	948	939	-.9	1,108	523	-52.8
Other, NEC	2,618	4,798	973	926	-4.8	1,645	3,872	135.4
Other Sci. NEC	8,461	9,727	5,306	5,747	8.3	3,155	3,980	26.1

NEC, not elsewhere classified.

SOURCE: National Science Foundation, Academic Science/Engineering: R&D Funds Fiscal Year 1983 (In press), Preliminary Table B-60.

APPENDIX C: FEDERAL INSTRUMENTATION PROGRAMS

Agency, Program Title	Description
Department of Defense: DOD-University Research Instrumentation Program	Five-year program to upgrade university research instrumentation sponsored by Army Research Office, Office of Naval Research, and Air Force Office of Scientific Research. Program goals: - To stimulate and support basic research that furthers the technological goals of DOD. - To support the training of graduate students in the use of research equipment. Requests are not considered for instrumentation with a total cost to DOD of less than $50,000 or more than $500,000. Requests for specialized research configurations of computers that are devoted primarily to specific DOD research programs are considered, provided that the total government contribution to the purchase cost of the computer equipment does not exceed $300,000.

University Matching	Annual Volume of Funding
Matching is encouraged but is not required and is not included in the criteria used for evaluating proposals. DOD funds awarded cannot be used for buildings or facilities modification, although such costs when borne by the university or other funding source may contribute to matching. Set-up costs may be included, but costs for continued operation and maintenance must be met by normal research support mechanisms.	Fiscal year 1983 was Phase I of the program. Thirty million dollars was allocated equally among the three armed services for each year of the program. - 2,500 proposals were received totaling $645 million in funding requests. - 200 awards were made to more than 80 universities. Fiscal years 1984 and 1985 comprise Phase II. Sixty million dollars will be equally distributed over the two years.

Agency, Program Title	Description
Department of Energy: University Research Instrumentation Program	Program goal is to stimulate and support basic research in those universities with existing DOE support. Funds are provided for acquisition costs of instruments. Costs of renovation and installation, operation and maintenance, service contracts, and technical support are not provided. The usable life span of the equipment must be estimated and the institution's plans for ensuring its continued availability during the first five years must be demonstrated.
National Science Foundation: Astronomical Instrumentation and Development Program	Program provides support for development and construction of state-of-the-art detectors and data-handling equipment, procurement of detection and analysis systems for telescopes at institutions that presently lack such systems, development of interactive picture-processing systems, very long baseline interferometric instrumentation, and application of new technology and innovative techniques to astronomy.

University Matching	Annual Volume of Funding
No specific fraction of matching is specified, but the level of matching will be a factor in the evaluation of applications. Matching can include shipping/installation and/or the renovation/modification of the physical space where the instrument will be located.	Five-year program projected to last through 1989. Fiscal year 1984 funding was $4 million. Fiscal year 1985 funding is $6 million.
Matching is not required.	Fiscal year 1981 funding was $5.9 million. Fiscal year 1982 funding was $6 million. Fiscal year 1983 funding was $6.7 million. Fiscal year 1984 funding was $9.6 million. Fiscal year 1985 funding is $7.9 million.

Agency, Program Title	Description
National Science Foundation: Biological Instrumentation Program	Program provides funds for purchase of multiple-user instruments in physiological, cellular, and molecular biology. Program supports the development of new instruments that will either extend current instrument capability in terms of sensitivity of resolution or will provide new and alternative techniques for detection and observation of physical or biological phenomena. Funds will not be provided for space renovation, installation, maintenance contracts, technical personnel, and operation of commercial instruments. However, the university must describe how maintenance and operation costs will be met. Personnel and shop costs may be requested for instrument development and construction.
National Science Foundation: Chemical Instrumentation Program	Program provides aid to universities and colleges in acquiring major items of multiuser instrumentation essential for conducting fundamental research in chemistry.

University Matching	Annual Volume of Funding
Matching is required. The exact amount (in the range of 25 to 50 percent) is negotiated with the university. Renovation of space and maintenance are acceptable as part of the university's matching only if accompanied by part of the purchase price.	Fiscal year 1983 funding was $5 million. Fiscal year 1984 funding was $6.2 million. Fiscal year 1985 funding is $7.4 million.
Matching is required, but the amount varies. In fiscal year 1984 the university share was 33 1/3 percent.	Fiscal year 1980 funding was $4.2 million. Fiscal year 1981 funding was $4.6 million. Fiscal year 1982 funding was $4.1 million. Fiscal year 1983 funding was $6.4 million.

Agency, Program Title	Description
National Science Foundation: Chemical Instrumentation Program (continued)	Program does not normally provide support for personnel, indirect costs, installation, or operating costs. When such support is necessary during the installation and start-up period for complex instrumentation, detailed justification must be provided. The university must provide information on the annual budget for maintenance and operation of the proposed instrument, other research support services and total operating budget, and technical support staff and maintenance expertise provided by the department. Proposals are evaluated on the basis of the ability of the department to ensure that the instrument will be well maintained and efficiently used.
National Science Foundation: Computer Research Equipment Grants	Program provides support for purchase of special-purpose equipment for computer research. The equipment must be necessary for the pursuit of specific research projects rather than intended to provide general computing capacity. It must be needed by more than one project and difficult to justify for one project alone. The total cost must be at least $10,000.

University Matching	Annual Volume of Funding
	Fiscal year 1984 funding totaled $10.2 million. - $1.3 million went to small schools with primarily undergraduate programs. - $80,000 was for a new program that provides funds to universities in states that have not fared well in funding. - $2.2 million was for regional instrumentation facilities. - Remainder of funding was for Ph.D.-granting institutions for equipment over $50,000. Fiscal year 1985 funding is about $10.2 million.
Universities must provide a minimum of 25 percent of the cost of the equipment and first-year maintenance as matching.	Fiscal year 1980 funding was $2 million. Fiscal year 1981 funding was $1 million. Fiscal year 1982 funding was $1.2 million. Fiscal year 1983 funding was $1.2 million. Fiscal year 1984 funding was $1.4 million.

Agency, Program Title	Description
National Science Foundation: Computer Research Equipment Grants (continued)	Funds for maintenance during the first year may also be requested. The university must provide a detailed plan for the maintenance and operation (M&O) of the instrument including the annual M&O budget that the department will allocate.
National Science Foundation: Earth Sciences Research Instrumentation Program	Program is intended to meet the need for specialized equipment that commonly is too expensive and of too broad a potential use to be justified by a regular research proposal. Program provides funds to purchase major research equipment, renovate and upgrade existing equipment, and develop new instruments that will extend current research capabilities. Support may be requested for regional facilities to provide access to large items of equipment by a broad segment of the research community. Personnel and shop costs may be requested for equipment development and construction. The costs of space renovation, installation, maintenance, technical personnel, and operation of commercial equipment ordinarily are not supported.

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is about $1.5 million.
No specific fraction of matching is specified, but the university contribution is a determining factor in the award. The university is encouraged to assume the costs of space renovation, installation, and maintenance as matching in addition to part of acquisition cost of the instrument.	Prior to 1983, funding was variable with most money coming from small research projects. Funding for fiscal years 1980 to 1982 was about $750,000 per year. Fiscal year 1983 funding was $2.5 million. Fiscal year 1984 funding the was $5 million. Fiscal year 1985 funding is $5 million.

Agency, Program Title	Description
National Science Foundation: Earth Sciences Research Instrumentation Program (continued)	The university must describe the provisions for maintenance of the equipment or facility and the source of funds to meet the costs of maintenance and operation. The ability of the institution to operate and maintain the equipment is a determining factor in the award.
National Science Foundation: Engineering-Automation Instrumentation and Sensing Systems Program	New program that supports research in instrumentation for all engineering disciplines. The scope will cover everything from fundamental research on instrumentation questions to research leading to development of instrumentation and/or proof of concept.
National Science Foundation: Engineering Research Equipment Grants	Program provides funds to purchase new equipment or to upgrade existing equipment. The equipment should be necessary for pursuit of specific research projects in areas normally supported by the engineering directorate. Funds are not provided for space renovation, installation, maintenance contracts, and the operation of commercial instruments. However, the university must provide a detailed statement of its intention to provide

University Matching	Annual Volume of Funding
Matching is required, but is negotiated on a case-by-case basis. The university share is expected to be at least 33 1/3 percent of the total cost of each item of equipment.	Fiscal year 1980 funding was $2.86 million. Fiscal year 1981 funding was $1.8 million. Fiscal year 1982 funding was $1.9 million. Fiscal year 1983 funding was $3.9 million. Fiscal year 1984 funding was $7.3 million. Fiscal year 1985 funding is about $7 million.

Agency, Program Title	Description
National Science Foundation: Engineering Research Equipment Grants (continued)	these facilities, if required. The ability of the university to provide essential supporting facilities and maintenance is a determining factor in the award.
National Science Foundation: Materials Research Instrumentation Program	Program provides support for purchase of major instruments needed for materials research and for development of new instruments that extend current measurement capability. Costs of space renovation, installation, maintenance contracts, technical personnel, and operation of commercial instruments ordinarily are not supported. Personnel and shop costs may be requested for instrument development and construction. The ability of the university to operate and maintain the instrument and the adequacy of shop and electronics support are determining factors in the award.
National Institutes of Health Division of Research Resources: Research Support Shared Instrumentation Grants Program	Program began in 1982 in response to recognition of the long-standing need in the biomedical research community to cope with rapid technological advances in instrumentation and the

University Matching	Annual Volume of Funding
Matching is required, but no specific fraction is specified. The level of funds provided by the university is a determining factor in the award. Assumption by the university of costs of space renovation, installation, maintenance contracts, and technical personnel is encouraged.	Fiscal year 1983 funding was $4 million. Fiscal year 1984 funding was $6.5 million. Fiscal year 1985 funding is $6.5 million.
Matching is not required.	Fiscal year 1982 funding was $3.7 million. Fiscal year 1983 funding was $14 million. Fiscal year 1984 funding was $19.7 million.

Agency, Program Title	Description
National Institutes Health Division of Research Resources: Research Support Shared Instrumentation Grants Program (continued)	rapid rate of obsolescence of of existing equipment. Program is a subprogram of the Biomedical Research Support Grant, and supports instrumentation used by three or more investigators. Program provides funds to purchase or update expensive shared-use equipment which is not generally available through other NIH mechanisms. Maximum award is $300,000. Program funds the acquisition of equipment only. The institution must meet those costs required to place the equipment in operational order as well as maintenance, support personnel, and service costs. If the funds requested do not cover the total cost of the instrument, an award will not be made unless the remainder of the funding is assured. The institution's ability to provide continued maintenance of the equipment is a determining factor in the award.
National Institutes of Health Division of Research Resources: Biomedical Research Technology Program	Program funds regional and national shared instrumentation centers. Its purpose is to develop and provide access to very sophisticated instrumentation and

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is $31.8 million.
Matching is not required, although some institutional contribution is encouraged.	Fiscal year 1980 funding was $15 million. Fiscal year 1981 funding was $16.8 million.

Agency, Program Title	Description
National Institutes of Health Division of Research Resources: Biomedical Research Technology Program (continued)	technology needed to solve basic biomedical and clinical research problems. These resources include core research programs for instrument and methods development, collaborative research programs, and programs providing service for users in biomedical research. The program provides funds for initial instrument purchase and installation. The grant pays the full cost of the core research not otherwise supported and supports aspects of the program required to provide access to outside users, such as personnel, maintenance, and supplies. Awards exceed $300,000, the ceiling for the BRS Shared Instrumentation Grants Program. The scope of the Biomedical Research Technology Program is broader--its facilities are located to maximize accessibility to a particular region rather than one university or department.
National Institutes of Health Division of Research Resources: Minority Biomedical Research Support Program	Program provides funds to institutions having an MBRS award for acquisition of new equipment or upgrading of existing equipment.

University Matching	Annual Volume of Funding
	Fiscal year 1982 funding was $17.7 million. Fiscal year 1983 funding was $23.5 million. Fiscal year 1984 funding was $31.4 million. Fiscal year 1985 funding is estimated to be $30.9 million.
Matching is not required.	Fiscal year 1983 funding was $1.3 million. Fiscal year 1984 funding was $1 million.

Agency, Program Title	Description
National Institutes of Health Division of Research Resources: Minority Biomedical Research Support Program (continued)	There is no limit on the cost of instrumentation requested; however, the maximum award is $135,000. When the total cost of the instrument exceeds $135,000, an award will not be made unless the remainder of the funding is assured. Support for construction, renovation, maintenance, or personnel is not provided. However, the institution's commitment to support of operation and maintenance of the instrument is a determining factor in the award.
National Institutes of Health National Institute of General Medical Sciences: Shared Instrumentation Program	Program was begun in 1978 to provide funds for purchasing new or updating existing major analytical research instruments that might not be justified fully for a single project, but can serve several projects on a shared basis. Program goals are to provide NIGMS grantees with better access to modern instrumentation and to promote the diffusion of new techniques among potential users. The program provides funds for instruments in the $30,000 to $100,000 price range. When funds exceeding that amount are requested, the application is passed automatically to the DRR Shared Instrumentation

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is $1 million.
The university is expected to demonstrate its commitment to the instrument by contributing at least half the costs for maintenance and technical support personnel. In addition, the university must provide for installation and any needed renovation of existing facilities.	Funding for fiscal years 1979 and 1980 was $9 million. No awards were made in fiscal year 1981. Fiscal year 1982 funding was $1.3 million. Fiscal year 1983 funding was $600,000. Fiscal year 1984 funding was $200,000. Fiscal year 1985 funding is $270,000.

Agency, Program Title	Description
National Institutes of Health National Institute of General Medical Sciences: Shared Instrumentation Program (continued)	Program. The NIGMS program will contribute to both instrument maintenance and support personnel. The amount of funding extended for the purpose is determined by customary review groups.

APPENDIX D: ANALYSIS OF LOAN SUBSIDY PROGRAMS

The potential utility of a loan subsidy program for scientific equipment is analyzed here in terms of hypothetical models and cost comparisons. Our assumptions about cost components are based on the experience of the Guaranteed Student Loan (GSL) Program.* The category of special allowance in the GSL program is called interest subsidy in this analysis. (The GSL category named interest subsidy is the interest paid while the student is in school and, hence, is not relevant to this analysis.)

We examined three alternatives: loan guarantee, loan guarantee with interest subsidy, and direct loan with low interest. The analysis uses the following assumptions:

- Market interest rate is 14 percent.
- Tax-exempt interest rate is 7 percent.
- Interest subsidy (the amount necessary to guarantee the same rate as tax-exempt borrowing) is 7 percent.
- Funding to be made available to the universities to purchase R&D equipment is to be increased by $100 million, about 23 percent of total spending on academic equipment in 1983.
- Administrative, insurance, and incidental costs of the loan programs to the government approximate 22 percent of total costs, which is the experience of the Guaranteed Student Loan Program.

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*Touche Ross & Co., Study of the Costs and Flows of Capital in the Guaranteed Student Loan Program, Final Report to the National Commission on Student Financial Assistance (Washington, D.C., March 1983).

LOAN GUARANTEE

Federal assistance in the form of a loan guarantee would primarily affect the credit rating of some universities, thus increasing their access to capital and reducing their interest expenses. This reduction, however, is likely to be relatively small. In addition, a loan guarantee program is not likely to increase total resources significantly.

LOAN GUARANTEE WITH INTEREST SUBSIDY

The loan guarantee with interest subsidy alternative was designed to increase the total capital available to universities for equipment, rather than to reduce the cost of debt for those already participating in the credit markets for that purpose. If an interest subsidy reduces the cost of funds to below the tax-exempt rate the strongest universities can obtain in financial markets, they might substitute federal loans for their own money. Universities that are less solid financially, or are in states that do not authorize the use of tax-exempt bonds for equipment purchases, could thus be crowded out. In addition, the total resources available to all universities might increase very little, if at all. The interest subsidy in this alternative, therefore, was pegged to achieve an interest rate roughly the equivalent of the tax-exempt rate.

Amortization of a $100 million, five-year loan at 14 and 7 percent interest and calculation of the interest subsidy are shown in Table D-1. The subsidy is a residual of interest payments calculated at 14 percent (assumed market rate) and 7 percent (assumed tax-exempt rate) and discounted at 7 percent. The interest subsidy would more than double if the repayment period were increased to 14 years.

The relative proportions of the costs to the government in this alternative are shown in Table D-2, which is based partly on the GSL program. As the table shows, the interest subsidy constitutes 77 percent of the total cost. Administrative costs for the GSL program tend to be relatively small, between 2 and 3 percent. It is possible, however, that in a smaller program, such as a loan guarantee with an interest subsidy, the administrative costs would be somewhat higher. The overall increase in cost to the government, nevertheless, should be negligible. Federal reinsurance, which accounts for 16 to 18 percent of cost in the GSL program, might be lower in a program of loan guarantees with interest subsidy, because most loans would be made to institutional borrowers rather than individuals. A reduction of 3 percent would

TABLE D-1 Amortization Table for $100 Million, Five-Year Loan

Year	Principal	Payment	Interest	Repayment of Principal	Balance
Annual Rate of 14 Percent					
1	$100,000,000	$29,128,355	$14,000,000	$15,128,355	$84,871,645
2	84,871,645	29,128,355	11,882,030	17,246,325	67,625,320
3	67,625,320	29,128,355	9,467,545	19,660,810	47,964,510
4	47,964,510	29,128,355	6,715,031	22,413,324	25,551,186
5	25,551,186	29,128,355	3,577,166	25,551,166	(3)
Annual Rate of 7 Percent					
1	$100,000,000	$24,389,069	$ 7,000,000	$17,389,069	$82,610,931
2	82,610,931	24,389,069	5,782,765	18,606,304	64,004,627
3	64,004,627	24,389,069	4,480,324	19,908,745	44,095,882
4	44,095,882	24,389,069	3,086,712	21,302,357	22,793,525
5	22,793,525	24,389,069	1,595,547	22,793,522	3

Year	Difference in Payment Required	Present Discounted Value (7 Percent Discount Rate)
1	$ 4,739,286	$ 4,429,239
2	4,739,286	4,139,476
3	4,739,286	3,868,669
4	4,739,286	3,615,579
5	4,739,286	3,379,045
Present value of payment difference stream (interest subsidy)		$19,432,008

SOURCE: Coopers & Lybrand.

TABLE D-2 Cost to the Government of a $100 Million, Five-Year Loan Program with Interest Subsidy

	Cost (dollars)	Percentage
Interest subsidy	19,432,008	77
Reinsurance	4,290,184	17
Administrative	504,727	2
All other	1,009,455	4
Total gross	25,236,374	
Total offsets	2,894,612	
Net outlays	22,341,762	

SOURCE: Coopers & Lybrand.

be expected to save the government $807,640 on a $100 million loan program.

DIRECT LOAN PROGRAM

In the direct loan alternative, the government is assumed to raise $100 million, which it then lends to universities at an interest rate of 7 percent, the rate available in the tax-exempt debt market. Compared with the loan guarantee with interest subsidy, this alternative entails small additional transaction costs, to raise the $100 million, and administrative costs, to manage the two streams of payables and receivables. On balance, these additional costs are expected to be negligible.

The key finding of our projections for the direct loan alternative is that the present discounted value of the cost to the government is the same, $19,432,008, as for the loan guarantee with interest subsidy described above, if the government borrows at the 14 percent rate assumed for the previous projections (see Table D-1). The reason is that the actual amount of subsidy--the difference between annual repayments from borrowers at a 7 percent rate, and the combined principal and interest (at 14 percent) falling due each year--is the same in both programs. If the government is able to borrow the $100 million at a lower rate of interest (as it might well be able to do in the Treasury bill market), then the direct loan program is the cheaper of the two.

The direct loan program does involve certain political considerations. The first is that the additional government borrowing would represent an increase in the national debt. The increase is essentially cosmetic, however, as the amount borrowed would be repaid, except for the interest subsidy, as in the loan guarantee with interest subsidy program. The second consideration relates to who receives the subsidies from the government. In a direct loan program, it would be the investors in the Treasury bill market (or other lenders to the government). In a loan guarantee with interest subsidy program, the beneficiaries would be the banks lending low-interest money to the universities by receiving federal payments, making total amounts received equal to receipts from loans at market rates.

APPENDIX E: REPRESENTATIVE STATE REGULATIONS

Purchasing Controls	Financing Controls	Utilization Controls
California[a]		
All contracts for purchase of equipment approved by Dept. of General Services.	Higher education financing authority finances facilities and equipment for independent institutions.	No formal controls. General requirements of demonstrable public purpose.
Competitive procurement for all purchases in excess of $100.	Public institution financing for facilities may include all equipment in original construction or renovations.	Joint public-private ventures increasingly common.
Special approvals required for data processing and telecommunications equipment.	Public institution financing may incorporate reserves for additions and improvements; unclear if replacement may be included.	
Act applies only to public institutions.	Legislation introduced to allow public institutions to participate in pooled equipment issues.	

Purchasing Controls	Financing Controls	Utilization Controls
California (continued)		
Public institution boards have delegated authority to approve contracts up to defined limits.	Legislation introduced for high technology financing for public and independent higher education.	
Connecticut[b]		
All contracts by Dept. of Admin. Services, unless DAS authorizes other state agency to acquire directly.	Health & education facilities authority finances equipment and facilities for public and independent institutions.	Public and independent institutions may jointly use any facilities and equipment.
DAS established equipment standardization rules for all agencies. May authorize noncompetitive procurement in emergencies.	Equipment financing only as incident to facilities projects.	Extensive use of quasi-public corporations for ownership of property both tangible and intellectual.
Competitive procurement required for purchases above $6,000;		

Purchasing Controls	Financing Controls	Utilization Controls
Connecticut (continued)		
below $6,000 preferred; not required below $300.		
Special rules for data processing and "similar" equipment set by DAS, but may waive for other agencies.		
Georgia[c]		
All equipment purchases through Dept. of Admin. Services from certified sources, with preference for items produced in-state.	Public and independent institutions have separate higher education financing authorities.	No explicit limitations.
DAS set standard specifications for all equipment.	For private institutions, equipment financed only as part of original construction or renovation.	All property of public universities vests with Board of Regents but can be alienated only with approval of Governor.

Purchasing Controls	Financing Controls	Utilization Controls
Georgia (continued)		
Competitive procurement except if cost under $500 or continuing procurement.	For public institutions, equipment may be separately financed.	
Technical instruments and supplies exempted from most purchasing controls, as is acquisition from U.S. govt.		
DAS administers statewide telecommunications and EDP, but universities exempted from mandatory provisions.		
Illinois[d]		
Purchasing carried out by each public agency, except for specified categories.	Educational facilities authority finances facilities and equipment of independent institutions.	Higher Education Cooperation Act encourages interinstitutional cooperation; has been defined to extend to cooperation between institutions and other public or nonprofit entities.

Purchasing Controls	Financing Controls	Utilization Controls
Illinois (continued)		
Competitive procurement required for equipment over $2,500; preferred for all.	EFA may issue pooled equipment bonds.	Statutory limitations on nonpublic use of equipment.
Special controls for leasing of computer and telecommunications equipment.	Public institutions may issue revenue bonds; other financing through general obligations of state.	
	Statutory limitation on term of all contracts, including leases; one-year maximum or appropriations period, with some exceptions.	
	Capital development authority finances public facilities, including appurtenant equipment.	
Iowa[e]		
Board of Regents conducts purchasing for public institutions.	Financing of equipment at public institutions only as part of facilities construction project.	No direct controls.

Purchasing Controls	Financing Controls	Utilization Controls
Iowa (continued)		
Advertise competitively for all procurements in excess of $25,000. Limited competition for other procurement. Operating funds requisitioned on as-needed basis within appropriated sums.	No private institution financing agency.	
Kentucky[f]		
Institutions may elect to control own purchasing bounded by provisions of the state's Model Procurement Code. [illegible] institutions may choose to use services of central stores, if greater savings can be achieved by [illegible] order large quantities of certain items.	Institutions have responsibility for financing of capital projects.	No state controls--institutions may have authority to provide best use of money for services rendered and goods purchased.

Purchasing Controls	Financing Controls	Utilization Controls
Maryland[g]		
Centralized control for all equipment acquisitions for public institutions, through Board of Public Works.	Public institutions may capitalize equipment and finance through general obligation bonds if useful life in excess of 15 years.	Strong statutory limitations on public university involvement in for-profit ventures.
Preference for Maryland suppliers.	No higher education facilities authority for private institutions. Some limited use of industrial revenue bond authority for comparable purposes.	
Special rule for acquisition of computers and software, with additional approval steps. (But legislation introduced to exempt all computer procurements for academic or research purposes.)	Extensive development of joint venture financing.	
Competitive sealed bids for items in excess of $750; agencies can adopt "small procurement procedures" for lesser amounts.		

Purchasing Controls	Financing Controls	Utilization Controls
Maryland (continued)		
Strict review of equipment requisition by BPW, with power to recommend substitution of "equivalents."		
New York[b]		
Purchasing by individual public system (State Univ. of NY, City Univ. of NY, statutory colleges, community college dists).	Public financing agencies (State Univ. Const. Fund and City Univ. Const. Fund) may finance equipment as well as facilities.	Dependent upon public system.
Purchases under $100 exempt from competitive procurement; up to $5,000 need not advertise for bids; beyond $5,000 full competitive procurement. State Univ. Const. Fund and CUNY and Dormitory Auth. equivalents may exempt contracts under $20,000.	State Dormitory Authority may finance facilities for lease to private institutions, with appurtenant equipment.	

Purchasing Controls	Financing Controls	Utilization Controls
North Carolina[i]		
Secretary of Administration receives requisitions and makes purchases on behalf of state agencies, except Univ. of North Carolina and community colleges.	Higher education facilities authority proposed but recently defeated in referendum.	Extensive joint public-private activity.
Competitive sealed bids for all purchases in excess of $5,000; Advisory Budget Committee sets requirements for lesser amounts.	Public financing includes equipment appurtenant to facilities project.	Extensive use of quasi-governmental entities.
Virginia[j]		
All purchases made with state funds must be by Dept. of General Services.	Higher education facilities authority finances equipment as part of facilities project, but may allow acquisition of equipment for "a period" after construction is completed.	Statutory authority for public institutions to contract with private institutions for services and facilities.

Purchasing Controls	Financing Controls	Utilization Controls
Virginia (continued)		
DGS standardizes all purchases and must grant waivers for exceptions.	Industrial Revenue Bond Act may be used to equip educational facilities (private), separate from construction.	Legislation approved for joint public institution-private sector high tech R&D activities; created Center for Innovative Technology.
DGS may exempt purchases below specified amount from its direct control, and may exempt classes of equipment.	Public institution financing of equipment as part of construction project.	
DGS may authorize state agencies to purchase directly; has done so for most higher education.		
All contracts competitive, with preference for Virginia goods.		
Agencies may set procedures for noncompetitive procurement for items less than $10,000, or available from a sole source.		

[a] Cal. Pub. Con. Code sections 10290-12121, 20650-20659; Cal. Educ. Code sections 81651-56, 81800-10, 94100-94213; Cal. Gov't. Code sections 11005, 13332-13332.16.

[b] Conn. Gen. Stat. Ann. sections 3-116a, 3-116b, 4-23j, 4-23k, 4-34, 4-36, 4-69 to 4-124, 10a-22, 10a-89, 10a-98 to 10a-98g, 10a-110 to 10a-110g, 10a-126 to 10a-136, 10a-150, 10a-176 to 10a-198.

[c] Ga. Code sections 20-3-53 to 20-3-60, 20-3-150 to 20-3-214, 50-5-10 to 50-5-11, 50-5-50 to 50-5-81, 50-5-160 to 50-5-169, 50-16-81, 50-16-160 to 50-16-162.

[d] Ill. Rev. Stat. ch. 172, sections 213.1 et seq., 307 et seq., 751 et seq.; ch. 144, sections 68 et seq., 181 et seq., 351 et seq., 1201 et seq., 1301 et seq.

[e] Iowa Code Ann. ch. 262, ch. 262A, ch. 263A.

[f] Ky. Rev. Stat. section 164.026; ch. 45A.

[g] Md. Ann. Code art. XII, sections 12-101 to 12-106; art. XVII, sections 17-101 to 17-107.

[h] N.Y. Educ. Law, tit. 1, art. 8-A, sections 370, 376; tit. 7, art. 125, sections 6201, 6213; tit. 7, art. 125-B, sections 6270, 6275.

[i] N.C. Gen. Stat. sections 116-53, 143-2 to 143-7, 143-49 to 143-56.

[j] Va. Code sections 2.1-422 to 2.1-548, 11-35 to 11-80, 15.1-1373 to 15.1-1391, 23-9.10:3, 23-14 to 23-30.03, 23-30.39 to 23-30.58.

SOURCE: Coopers & Lybrand.

APPENDIX F: REPRESENTATIVE STATE STATUTES AUTHORIZING THE ISSUANCE OF BONDS TO FUND HIGHER EDUCATION FACILITIES

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment* Includable as Separate Project
ALABAMA Educational Building Authorities Act, Ala. Code Sec. 16-17-1 to 16-17-19 (1983)	Yes	Yes
ARIZONA Industrial Development Plans for Municipalities and Counties, Ariz. Rev. Stat. Ann. Sec. 9-1151 to 9-1196 (1983)	Yes	No
CALIFORNIA California Educational Facilities Authority Act, Cal. Educ. Code Sec. 94100-94213 (1983)	Yes	Yes
CONNECTICUT Connecticut Health and Educational Facilities Authority, Conn. Gen. Stat. Ann. Sec. 10a-176 to 10a-198 (1983)	Yes	Pending
DISTRICT OF COLUMBIA Taxation and Fiscal Affairs, D.C. Code Ann. Sec. 47-321 to 47-334 (1983)	Yes	Yes

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
FLORIDA Higher Education Facilities Authority Law, Fla. Stat. Ann. Sec. 243.18 - 243.40 (1983)	Yes	No
GEORGIA Private Colleges and Universities Authority Act, Ga. Code Ann. Sec. 20-3-200 to 20-3-214 (198); Georgia Education Authority (University) Act, Ga. Code Ann. Sec. 20-3-150 to 20-3-181 (1983)	Yes	Varies**
ILLINOIS Educational Facilities Authority Act, Ill. Rev. Stat. ch. 144, Sec. 1301-1326 (1981); Board of Regents Revenue Bond Act of 1967, Ill. Rev. Stat. ch. 144, Sec. 351-363 (1983); Bonds for Permanent Improvements at State Educational Institutions Ill. Rev. Stat. ch. 127, Sec. 307-313 (1983); Capital Development Bond Act of 1972, Ill. Rev. Stat. ch. 127, Sec. 751-765 (1983); State Colleges and Universities Revenue Bond Act of 1967, Ill. Rev. Stat. ch. 144, Sec. 1201-1213 (1983); Illinois Building Authority Act, Ill. Rev. Stat. ch. 127, Sec. 213.1-1 to 213.16 (1983)	Yes	Varies**

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
INDIANA Indiana Educational Facilities Authority Act, Ind. Code Ann. Sec. 20-12-63-1 to 20-12-63-29 (1983)	Yes	Yes
IOWA State Universities Buildings Facilities and Services Revenue Bonds, Iowa Code Ann. Sec. 262A.1-262A.13; Medical and Hospital Buildings at University of Iowa, Iowa Code Ann. Sec. 263A.1-263A.11	Yes	No
KENTUCKY Property and Buildings Commission, Ky. Rev. Stat. Sec. 56.440-56.495	Yes	No
MINNESOTA Minnesota Higher Education Facilities Authority, Minn. Stat. Ann. Sec. 136A.25-136A.55 (1983)	Yes	Pending
NEW JERSEY New Jersey Educational Facilities Authority Law, N.J. Rev. Stat. Sec. 18A:172A-1 to 18A:72A-39 (1983)	Yes	No

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
NEW YORK City University Construction Fund Act, N.Y. Educ. Law Sec. 6270-6282; State University Construction Fund Act, N.Y. Educ. Law Sec. 370-384; Board of Higher Education in the City of New York, N.Y. Educ. Law Sec. 6201-6216; New York Dormitory Authority Act, N.Y. Pub. Auth. Law Sec. 1675-1694	Yes	Varies**
OHIO Higher Educational Facility Commission, Ohio Rev. Code Ann. Sec. 3377.01-3377.16	Yes	No
SOUTH CAROLINA Educational Facilities Authority Act for Private Nonprofit Institutions of Higher Learning, S.C. Code Ann. Sec. 59-109-10 to 59-109-180	Yes	No
TEXAS Higher Education Authority Act, Tex. Educ. Code Ann. Sec. 53.01-53.46	Yes	No

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
VERMONT Educational and Health Buildings Financing Agency, Vt. Stat. Ann. tit. 16, Sec. 3851-3862	Yes	No
VIRGINIA Industrial Development and Revenue Bond Act, Va. Code Sec. 15.1-1373 to 15.1-1391 (1983); Bonds and Other Obligations, Va. Code Sec. 23-14 to 23-30.03 (1983); Educational Facilities Authority Act, Va. Code Sec. 23-30.39 to 23-30.58 (1983)	Yes	Yes
WASHINGTON Washington Higher Education Facilities Authority, Wash. Rev. Code Ann. Sec. 28B.07.010-28B.07.920 (1984); Wash. Rev. Code Ann. Sec. 28B.10.300-28B.10-335 (1984)	Yes	No

* Equipment acquired after construction of the facility.

** At least one, but not all, of the identified statutes in these states extends to after-acquired equipment.

SOURCE: Coopers & Lybrand.

APPENDIX G: IOWA STATE UNIVERSITY RESEARCH EQUIPMENT ASSISTANCE PROGRAM

THE BEGINNING OF REAP

The Research Equipment Assistance Program (REAP) at Iowa State University (ISU) was developed in the early 1970s because of a suggestion made by an advisory committee studying equipment problems at the university. This committee believed that an equipment sharing and loan program would make it easier for faculty members contemplating projects involving equipment to perform preliminary experiments. Implementation began with the part-time efforts of the late Alfred J. Bureau, then Assistant Professor of Physics, and Roger G. Ditzel, then Assistant to the Vice-President for Research. As a result of initial studies, a project was initiated in September 1972 to gather information on the use and availability of major research equipment at the university.

On February 1, 1974, the National Science Foundation Research Management Improvement Program funded a research proposal on this subject submitted by Iowa State University. The objective of this research was to develop and demonstrate a system for improved utilization of high-value research equipment that would increase research productivity. The functions involved in the research program included (1) information gathering, (2) inquiry processing based on requests representing equipment needs, (3) user education, (4) computer support, and (5) maintenance, replacement, and storage requirement studies.

Through this study, it was determined that any equipment assistance system should provide:

- a means of identifying and locating usable, highly diversified research equipment to allow planned research to be conducted without unnecessary new item purchases;
- information on availability for use by others of equipment items assigned to and used part of the time by one individual or research unit;
- a means of identifying unused equipment so that provision can be made for proper storage and necessary maintenance;
- a capability for knowledgeable decision making relative to disposal of obsolete or high maintenance cost items; and
- a means of retrieving problem-solving types of information, for example, potential spare parts sources on the campus.

A boundary condition on any such system exists and must be recognized in its structuring and implementation. That boundary is one of acceptance by the university researcher. No matter how sophisticated or well planned the system, it cannot succeed without the overt cooperation of the majority of researchers. If researchers perceive it as "taking their equipment away," they will not cooperate.

RESULTS OF THE RESEARCH PROJECT

As a result of the research project, investigators believed it was possible and economically feasible to implement an equipment information and sharing system to improve the productivity of university research personnel. With proper structuring and a low-key, nonthreatening introduction of a system designed to be responsive to needs, it was thought that researchers would cooperate and take advantage of the benefits offered.

When the grant period ended, over 2,500 items of research equipment had been examined and cataloged, acceptance by ISU researchers of the philosophy and mechanics of sharing had been achieved, and four volumes of information on the developed system, plus videotapes and slide shows, were made available to other universities.

RESEARCH COMPLETED; REAP CONTINUES

Because of the successful findings of the research study, the university has continued to support the REAP program since the grant expired. The program is administered by the Office of the Vice-President for Research. By 1974, a central office was established to serve as a communications center and focal point for the program and was staffed by a full-time clerk. This office is purposely located in an education and research building and not in the central administrative building. (It was felt that faculty members might be more comfortable and willing to use the service if it were in their own setting.)

The central office handles all inquiries and information processing. An inquiry is defined as a request to the REAP central office for assistance in relation to equipment. The inquiry may relate to the need for equipment, spare parts, operating manuals, help in definition of equipment needs to carry out a certain task, etc. Inquiries may be satisfied by a loan of equipment from the REAP office to the researcher's department, by a loan from one department to another, by researchers' sharing a piece of equipment in the same location, by finding minor parts, by providing information or manuals, or by referring the inquirer to others who have the same equipment. Since the inception of the program, the rate of inquiries has greatly increased. The tabulation below shows the total inquiries for the 12 years 1973-1984 and includes the number of those inquiries satisfied or not satisfied. It has been found that the high success rate in satisfying inquiries has been a major factor in the positive image the REAP program enjoys.

REAP Inquiries

Calendar Year	Total Number	Number Satisfied	Number Unsatisfied
1973	42	33	9
1974	208	168	40
1975	[illegible]	335	60
1976	953	799	154
1977	2,236	1,754	482
1978	2,108	1,672	436
1979	1,924	1,724	200
1980	2,201	2,012	189
1981	2,322	2,175	147
1982	2,173	2,029	144
1983	2,021	1,904	117
1984*	1,445	1,412	33

*Includes nine months of data (January-September).

REAP CATALOG

One of the first goals of REAP was to generate a catalog of existing equipment, with an estimate of the availability of the equipment for loan or transfer. The June 1984 listing contained nearly 10,000 items (each with an initial acquisition cost of $500 or more) having a total value of nearly $30 million. It is estimated that about 90 percent of all research equipment on campus is recorded in the computerized REAP catalog.

RESEARCH TECHNICAL ASSISTANCE GROUP

One function of the program that has proven to be exceptionally successful has been the capability of providing expert repair and calibration of most items of equipment. This has led to the recent development of a separate program known as the Research Technical Assistance Group (RTAG). RTAG complements the repair service of other university shops by offering minor repairs of balances, microscopes, nuclear counting systems, mass spectrometers, gas chromatographs, spectrophotometers, and electron microscopes. A major service is the diagnosing of equipment problems with subsequent referral to other university repair shops.

SUCCESS OF REAP

Perhaps the ultimate testimony to the importance of REAP was provided in 1978 by an "important notice" addressed to the presidents of U.S. universities by Richard C. Atkinson, then Director of NSF. In it he called attention to the Iowa State REAP system and recommended that others follow suit.

The value of REAP and its spin-off, RTAG, to Iowa State University is great. The number of inquiries alone proves that the program is popular and heavily used. In terms of actual dollars saved due to satisfied inquiries, records indicate that the REAP program has saved the university nearly $4 million since it began in 1973. In estimating equipment value as a benefit, the gross value of the item is not used. Instead, the length of time of the loan is taken into account and a "pro rata" value used, in order to arrive at a realistic equipment benefit value. Any equipment on loan for more than 100 days (which includes permanent transfers as well) is assumed to have produced savings equivalent to the full value of the equipment.

The following system is used based on acquisition cost or value of the item:

- three percent per day for a loan span of one to three days,
- ten percent per week for a time span of four days to three weeks,
- thirty percent per month for a time span of three weeks to 3 1/3 months, and
- one hundred percent for loans over 3 1/3 months.

For low-value items, a minimum transaction value of $5 is used. This method for computing savings has been approved by the General Accounting Office in Washington, D.C.

In addition to the savings mentioned above, many dollars are saved by RTAG's ability to make expensive equipment repairs (which sometimes results in the elimination of expensive service contracts).

QUESTIONS

For further information regarding the REAP program at Iowa State University, please contact Wayne Stensland, Manager, REAP, 103 Physics, Iowa State University, Ames, IA 50011 (telephone: 515/294-5536).

SOURCE: Vice-President for Research, Iowa State University (October 1984).

APPENDIX H: EXAMPLES OF DEBT FINANCING

EXAMPLE 1: REVENUE BOND ISSUE BY STATE UNIVERSITY

Description

Revenue bonds were issued by a state university to finance:

- refunding of existing notes,
- construction of new facilities at the university hospital,
- debt service reserve of the new issue, equaling the maximum annual debt service,
- construction period interest, and
- expenses incurred for bond issuance.

The bonds represent a limited obligation of the university regents and are secured by the gross revenues of the hospital. The bonds do not represent a debt obligation of the state.

Decision Factors

There are three main reasons why the university issued long-term debt.

1. The university hospital's funding requirement was substantial. The revenue bonds allowed the institution to minimize its borrowing cost, raise the necessary capital, and provide a debt repayment schedule that could be met out of hospital revenues.
2. The project was long term and included the construction of new buildings. The bonds allow the institution to match the life of the asset to the period over which the debt will be repaid.
3. During the past decade, the issuance of revenue bonds has become the primary source of capital for construction projects and major equipment purchases.

Terms

Amount of Issue:	$110,000,000.
Period:	The total issue was for 30 years. However, the individual bonds have maturities scheduled annually over the 30 years. The university also has the option to buy back the bonds from the investors before the maturity date (i.e., early redemption of bond).
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 6.5 percent to 9.875 percent. The interest rate on the bond is referred to as the coupon rate.
Additional Fees:	The issuance cost of the bonds totaled $3.5 million, which included financing and related costs and original issue discount.
Security Required by Lender:	A portion of the bond proceeds was set aside to establish a debt service reserve fund.
Terms Required by Borrower:	The bond represents a limited obligation of the university and is secured by the hospital's revenue.
Type of Project:	Ambulatory care facility.

Features

Obligation

The bonds are secured by the financial resources of the hospital. The hospital is required to maintain certain financial operating ratios, which would ensure that there are sufficient funds to meet the bond debt service. The rate covenant states,

> The hospital's annual net revenues (gross revenues minus expenses) are at least 125 percent of the annual debt service payments (interest plus principal).

If this ratio is not maintained, the university regents are responsible for taking corrective action. The bonds will be serviced by the revenues generated by the institution and the debt service reserve fund.

Security

The bonds are secured by the debt service reserve fund, which is established at the time the bonds are sold. The reserve contains sufficient funds to cover the maximum possible annual debt service.

Preparation of Official Statement

The revenue bond statement presents detailed financial information on the university and the hospital to demonstrate the source of revenues to potential investors.

Additionally, a detailed financial feasibility study was prepared for the construction project. These studies are used both to demonstrate financial soundness to investors and, when necessary, to provide required data for the State Certificate of Need process, through which state health planning agencies control the expansion of health care facilities. In this study, the investor was shown:

- assessment of the need for hospital services in the area,
- review of economic factors that would affect the success of hospital operations,
- review of forecasts for the hospital's utilization rates for services, and
- review of the financial forecasts, including the factors influencing revenue and cost estimates.

EXAMPLE 2: REVENUE BOND POOL

Description

Revenue notes were issued by a state educational authority to finance equipment purchases and rehabilitation projects for 15 private colleges within the state. The notes are limited obligations of the authority, payable only out of revenues and pledged funds of the participating private institutions. The revenues consist primarily of the loan repayments made by the colleges according to their debt repayment schedule as stated in their individual loan agreements with the authority.

Decision Factor

Fifteen institutions participated in the program.

The individual institutions' loans ranged from $17,745,000 to $120,000 for a period of two to seven years. One institution, a large private university, had the largest loan amount of $17.7 million for equipment acquisition and construction over a five- to seven-year period. Participation in the pool provided both large and small institutions access to tax-exempt debt. Generally, only large institutions would be able to issue their own bonds because of their established credit ratings.

Terms

Amount of Issue:	Total issue was approximately $50 million.
Period:	The issue has maturities scheduled over two- to seven-year periods as stated on the individual bonds.
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 6.25 percent to 8.75 percent. The interest rate on the bond is referred to as the coupon rate.
Additional Fees:	The issuance cost of the bonds totaled $2 million, including basic issuance cost, insurance premium, and underwriters' discount.
Security Required by Lender:	$5 million of the bond proceeds were set aside to establish a debt service reserve.
Terms Required by Borrower:	The participating institutions enter into an individual loan agreement with the educational foundation authority.
Type of Equipment:	Computers and other equipment for research, telecommunications, and energy conservation; and building renovations.

Features

Administration

Each college or university enters into a separate loan agreement with the authority. These loan agreements are based on the useful life of the college's equipment purchase and the college's credit worthiness. The college is required to make semiannual debt service payments to the authority, reflecting principal and interest payments, insurance premium amortization, issuance cost amortization, administrative cost, investment earnings shortfall, and any other authority-required payment.

Credit Requirements

The participating colleges entered into three types of loan agreements: (1) an unsecured general obligation to make debt service payments; (2) a general obligation to make debt service payments secured by real or personal property of the college; and (3) a general obligation to make debt service payments secured by real or personal property of the college, as well as a bank letter of credit.

In this issue, the pool includes both colleges with strong credit ratings and those without any proven credit experience. The three types of loan agreements provide for the necessary credit enhancements to obtain a favorable credit rating for the issue without penalizing the financially stronger colleges with a higher interest rate than these larger institutions would normally obtain on an individual bond.

Evaluation Criteria

The authority and the insurer of the issue reviewed the individual college's financial condition to determine eligibility in the program. The colleges were required to maintain a minimum two-to-one available assets to general liabilities ratio for the latest fiscal year, as well as to generate positive unrestricted current fund earnings after expenditures and mandatory transfers. Additionally, nonfinancial indicators were reviewed, such as enrollment data and trends.

Special Considerations

The insurer has committed to the issue an insurance policy that will insure the payment of principal of and interest on the bond. In the event there are not sufficient amounts available in the debt service fund and the debt service reserve fund to make debt service payments, the authority's trustee notifies the insurer of the deficient amount, and the insurer is obligated to pay the deficient amount according to the terms of the insurance policy.

EXAMPLE 3: INDUSTRIAL DEVELOPMENT BOND

Description

The industrial development bonds were issued by two county development authorities to provide funds to the research foundation for the construction of and equipment for a scientific and technical research facility and the purchase of an existing research facility from a private corporation. The research foundation, a state nonprofit corporation, has entered into a loan agreement with each issuer, in which the issuers loan the bond proceeds to the foundation for the research facility projects. The loan agreements require the foundation to pay the principal, premium (if any), and interest on the bonds, together with all associated costs and expenses. The foundation will lease the facilities to an affiliated research corporation of the state university and to a private corporation. The lease to the private corporation is incidental to the transaction with only a small portion leased back to the corporation selling the facility as a condition of the sale. These lease payments will be the revenue source for the debt repayment. The university has planned to fund its lease payments (i.e., bond retirement) entirely through indirect cost recovery.

Decision Factor

The university had considered raising the funds through a state building authority. However, the construction costs would have been $25 per square foot higher under the state authority than with the industrial development bonds. Additionally, the state building authority's financing process is oriented to academic rather than research projects; it is cumbersome and slow, with numerous regulations. In issuing the industrial development bonds, there is some risk if the federal government contests the arms' length relationship between the university and the foundation. However, in the instant case, the arm's length relationship has been recognized by the government.

Terms

Amount of Two Issues:	Approximately $17.2 million and $7.3 million.
Period:	The larger issue has maturities scheduled over 1- to 20-year periods as stated on the individual bonds. The smaller issue has maturities varying over 10 years.
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 5.5 percent to 9.625 percent. The interest rate on the bond is referred to as the coupon rate. Additionally, 1.25 percent of the amount of 103 percent of outstanding bonds is payable annually as a letter of credit fee.
Additional Fees:	The issuance cost of the bonds totaled $696,000, including financing, legal, printing, and miscellaneous expenses. Legal fees alone were $90,000. The first year's letter of credit fee was $340,000.
Security Required by Lender:	As part of the debt service requirements, a sinking fund will be started in year 13 for bonds maturing in year 20. (Note: A sinking fund represents an accumulation of funds by the issuer over a period of time to be used for retirement of debt, either periodically or at one time.) The letter of credit bank required security interests in the assets of the projects.
Terms Required by Borrower:	Though two counties issued the industrial development bond, the bonds are to be repaid by the foundation.
Type of Project:	The smaller issue was used by the foundation to purchase and renovate an existing research complex consisting of 50+ acres of land and 130,000 square

feet of office and laboratory space. The larger issue was used to purchase land and to design and construct a six-story 190,000 square foot laboratory building adjacent to the campus.

Features

Obligation

The bond investors will look to the letter of credit bank, which will look to the foundation for repayment. The bonds are a limited obligation of the issuing authorities and do not represent any indebtedness of the state.

Security

The primary security for the issue is the letters of credit and confirming letters of credit. In the event the foundation defaults on its loan agreement, the bond trustee will draw the necessary funds from the letter of credit bank to buy all bonds from the bond holders. If the letter of credit bank dishonors its obligation, the bond trustee will draw upon the confirming letter of credit bank to make payment. This arrangement allowed a Standard & Poor's AAA rating, though the foundation was essentially without assets. The letter of credit banks are secured by security interests in the research facility's land, buildings, and equipment. The foundation has assigned the facility's rents and leases. The university's affiliated research corporation is obligated to pay one year's debt service to the letter of credit bank in the event of foundation default and agrees to maintain its net worth at least at that level.

Administration

The foundation was formed for the purpose of supporting research activities of public and nonprofit colleges and universities in the state. It is considered a charitable, educational, and scientific organization exempt from federal income taxes. The foundation has no plans to undertake any fundraising and expects to rely upon rent charges from the research institute for the use of the facilities. The foundation has no long-term lease or contractual commitments from the research institute and its affiliated university.

EXAMPLE 4: STATE UNIVERSITY LINE OF CREDIT

Description

The university established a standby line of credit with a state commercial bank for the purpose of purchasing self-liquidating equipment. The line of credit is drawn upon by department heads or principal investigators on an as-needed, project-by-project basis. Their requests for funds are presented in loan agreements that specify the use of funds, the period of need, and the revenue source for repayment. Once these requests are reviewed, the funds are drawn from the line of credit within funding limits set by the Board of Regents and the lending limit agreed to by the bank.

Decision Factor

The university had experienced difficulty in finding adequate funding for equipment related to instructional and research activity. Funds from general operating budgets had been largely used for instructional equipment needs and had not adequately met the needs of the research programs. The university has found that its faculty's ability to continue a high level of externally sponsored research is dependent on its ability to obtain state-of-the-art equipment. With the recent changes in OMB Circular A-21 which allow the university to be reimbursed for interest on equipment purchases over $10,000, the university decided to obtain a line of credit, which could be used to acquire self-liquidating equipment over $50,000. Equipment financed through the line of credit in connection with external grant or contract arrangements would qualify as self-liquidating because both principal and interest on borrowed funds would be fully recovered from the grant or contract over the financing term.

Since establishing the equipment financing plan, the university has encountered some difficulty in receiving specific grant approval from at least one agency for the reimbursement of financing cost. When the line of credit plan was being considered, a description of the plan was sent to and discussed with Department of Health and Human Services, National Institutes of Health, National Science Foundation, Office of Naval Research, and the National Aeronautics and Space Administration. All agreed that the plan was appropriate and conformed to A-21 guidelines.

The line of credit has only been used to acquire equipment for one grant. The cost of the equipment will be covered by the grant funds. However, the interest costs are being paid out of a private gift fund because the sponsoring agency denied the request for reimbursement of interest cost.

Terms

Amount of Issue:	The ceiling for the line of credit was negotiated at $2 million.
Period:	The line of credit was negotiated for a five-year period with options to renew. Either the bank or university can terminate the contract at any time except with respect to outstanding loans.
Interest Rate:	Stated at about two-thirds of the bank's prime interest rate.
Additional Fees:	None.
Security Required by Lender:	None.
Terms Required by Borrower:	The bank will make loans to the university on a project basis with actual lending occurring only if the grant is awarded or if user fee terms are agreed upon to cover debt service.
Type of Project:	Various scientific instruments.

Features

Agreement

The university's Board of Regents approved the line of credit agreement after a competitive bid process in which a number of bank proposals were reviewed. The terms of the agreement specified:

- the ceiling of the line of credit,
- a commitment for lending on a project basis rather than in a lump sum,
- interest on a tax-exempt basis,
- interest rate established as an index to the bank's prime interest rate, with the rate for each individual loan set at the time a draw on the line of credit is negotiated, and

- that the agreement can be terminated at any time by either party except with respect to outstanding loans.

University Procedures

The principal investigator or department head seeking external funds for research equipment over a prescribed amount prepares a request for funds to the vice-president for educational development and research. This request presents a justification for the need and the funding requirements. The request has to describe the method for repayment as follows:

1. Existing grants that have a multiple year funding period could be rebudgeted. This could represent one or more principal investigators.
2. Equipment financing could be proposed in a grant application.
3. User charges and fees could be from external and/or internal users.

The request will be reviewed, and the cost analysis performed to determine the financial resources required to liquidate the debt. Approved requests are forwarded to the university business officer who maintains the banking relationships with the line of credit bank. The business officer will contact the bank to determine the terms of the new loan. If the terms, interest rate, index, and maturity are favorable, the business officer will request the bank to commit the funds to the new loan.

Once the loan is executed and funds transferred to the university, a loan account is established in the university plant fund. The equipment is purchased from this account. To provide an audit trail for liquidation of the debt, plant fund expenditures will be reimbursed through charges to the grant account in the current restricted fund or through transfers of depreciation amounts from the service account. The Board of Regents is to receive a monthly status report on the loans made from the line of credit. Additionally, the Board of Regents is to be notified when the line of credit ceiling has been reached.

EXAMPLE 5: ACQUIRING BIOMEDICAL EQUIPMENT

Description

The university obtained a demand note for a variety of funding requirements, including both instructional uses and research needs. The specific demand note was obtained after a competitive bid process in which proposals from a number of lending institutions were reviewed.

The demand note was used to finance the acquisition of a specialized piece of equipment for the radiology department of the medical school. The department needed to acquire the equipment immediately for research, but the hospital would not be able to use it for patient care, as third-party payers, specifically Blue Cross, considered its use experimental.

Decision Factor

The university decided to obtain a demand note to acquire equipment that the university had normally leased. The note provided a cheaper form of financing than leasing. However, the university still leases small pieces of equipment such as copiers. When the university was first considering the demand note, there were several projects, academic as well as research, that needed temporary or short-term funding. The university had a general set of guidelines for selecting the projects to fund with the demand note proceeds. All funds had to be used within six months because of arbitrage restrictions.

Since the time the demand note was obtained, several projects have repaid their debt or replaced the debt with long-term financing. Other projects have been substituted as funds are replaced.

Terms

Amount of Issue:	$15 million.
Period:	Five-year period with cancellation clauses.
Interest Rate:	Stated at about one-half of prime interest rate.
Additional Fees:	The university obtained a backup line of credit that cost an additional 1/2 percent.
Security Required by Lender:	The lender was a mutual fund. The university pledged its unrestricted endowment funds as collateral.

Terms Required by Borrower:	None.
Type of Project:	State-of-the-art equipment for the radiology department costing $1.4 million.

Features

The radiology department had an immediate need for the equipment but had insufficient funds to purchase the item. Access to the demand note proceeds enabled the department to acquire the equipment and pay for it later.

The demand note is serving as an intermediate financing instrument. The radiology department pays only the interest on the loan, and the hospital will repay the loan principal in two years from its capital outlay budget. In two years, the hospital will be able to justify the use of the equipment in patient care. Until that time, the department will cover the line of credit interest cost through user charges.

At the time the equipment is transferred from experimental to clinical use, it may be necessary to apply to the state health planning agency for a Certificate of Need under health planning statutes. The procedures vary from state to state and also over time, so that the precise requirements will not be known until the time for transfer.

EXAMPLE 6: MUNICIPAL LEASE

Description

Telecommunications equipment was acquired for a state university through its affiliated foundation. In this municipal lease, the university was the lessee and a bank was the lessor. The title to the equipment passed to the university at the end of the lease term.

Decision Factor

The municipal lease was used by the university to finance equipment acquisition because the state restricted the university from entering into multiyear indebtedness. The university was able to acquire the equipment with the municipal lease because the lease is renewed each fiscal year. The cost of the lease can also be passed on to federal grants and contracts for which the equipment is used.

Terms

Amount of Issue:	$500,000.
Period:	Municipal lease is written on a yearly basis with annual renewal options. The effective length of the lease, including renewal options, is six years. At the end of this time, the university will receive title to the equipment.
Interest Rate:	Less than 10 percent.
Additional Fees:	Administrative fee to the foundation calculated as a percent of the principal amount of the lease.
Security Required by Lender:	Security interest in the purchased equipment.
Terms Required by Borrower:	The university had the option to cancel the lease on a year-to-year basis in the event that funds were not appropriated for the lease.
Type of Project:	Telecommunications equipment.

Features

The foundation handles the administrative and control procedures for arranging the municipal lease. In this case, the university Atmospheric Science Department had need for telecommunications equipment. This need was documented and reviewed.

The municipal lease was open for bid, and the proposal with the most favorable terms was accepted. Because of state requirements, the finalization of the municipal lease agreement requires a lengthy approval process. A municipal lease transaction may require a tax-exempt opinion from legal counsel if the lessor requests one.

In the department's lease request, the equipment acquisition has to be justified. The department also has to explain the source and frequency of revenue to repay the debt and has to incur the cost of equipment insurance.

The department is responsible for funding the debt. It should be noted that the university in this case cannot borrow except for self-sustaining enterprises.

EXAMPLE 7: ADJUSTABLE RATE OPTION BOND

Description

The revenue bonds were issued by a state educational authority to fund a facilities project at a private university, including:

- construction of the university computing center,
- purchase of existing land and buildings for use as research, education, and student activities facilities,
- renovation and construction of laboratory facilities for the biology and chemistry departments,
- acquisition of equipment for the computing center,
- acquisition of apartment buildings for student housing, and
- construction and renovation of civil and chemical engineering laboratories.

The university will initially lease to the authority the various existing facilities referred to under project facilities. In turn, the university will sublease the facilities back from the authority and use the bond proceeds to complete renovation and construction of these facilities. The bonds will be payable solely from the university's sublease payments to the authority. The bonds are limited obligations of the authority. The bonds are not a liability of the state or any political subdivision of the state.

Decision Factors

The major reason that the university issued an adjustable rate bond (ARB) was the low interest rates in the short-term market versus the long-term fixed rate debt market. In the first year, the ARB had 6 1/4 percent interest. If the university had issued a long-term fixed rate debt instrument, the interest rate would have been 10 percent. The savings in first-year interest were significant. Though the bond's interest rate will be adjusted annually, the university has the option to convert to a fixed rate if long-term interest rates become favorable. Many institutions are using ARBs because of the favorable market conditions, including low short-term interest rate as compared to long-term rates and quick placement of bonds with investors.

Terms

Amount of issue:	$35,000,000.
Period:	The total issue was for 20 years. However, the bond holders have the right to tender (i.e., to have their bonds repurchased by the university) at a price equal to 100 percent of the principal amount on the annual anniversary of the issue date. The university has the option to redeem the bonds (i.e., to buy back the bonds from the bond holders) after one year from the date of issue. There are also optional redemption provisions that the university may exercise. Additionally, if the bonds are converted to a fixed interest rate, the bond holders will no longer have the right to tender their bonds.
Interest Rate:	The interest rate at the date of issue was 6 1/4 percent. Annually, on the anniversary of the issue date the interest rate will be adjusted to reflect changes in the interest rate index. The indexing agent of the issue will be responsible for determining the adjusted interest rate on an annual basis, according to an average yield of at least 20 twelve-month tax-exempt securities with a comparable debt category and rating of the university's bond.
Additional Fees:	The issuance cost of the bonds totaled more than $500,000.
Security Required by Lender:	Under the indenture agreement, the university is required to maintain cash and securities with a trustee to pay principal and interest to bond holders in the event that sublease revenues are insufficient to cover debt service. Initially, the university pledged to maintain unrestricted assets in the amount of $37 million, which will be reduced as bonds are retired.

Terms Required by Borrower:	The university has the right to convert the bonds from an adjustable interest rate to fixed interest rate. Prior to the conversion to a fixed interest rate, the bond holders have the right to tender (i.e., return) their bonds for purchase by the university.
Type of Project:	Various research and institutional facilities as described above.

Features

Administration

The authority will issue the bonds and place the bond proceeds with the trustee for distribution to the university. Under a sublease agreement with the authority, the university will receive the bond proceeds for construction and renovation of project facilities. In turn, the university's sublease payments to the authority will cover the principal, premium (if any), and interest payments. The university would be required to fund any tendered bonds if the returned bonds could not be remarketed and replenish the debt service reserve fund if the reserve is reduced. In the event that a bond holder tenders his bond to the university, the remarketing agent will try to the best of its ability to resell the tendered bonds.

Adjustable Interest Rate

The interest rate on the bonds will be adjusted on an annual basis based on the index defined above under interest rate in the section on terms. The rate will be determined by the remarketing agent to be the rate that equals but does not exceed the interest rate necessary to sell all of the bonds tendered.

Conversion to a Fixed Interest Rate

At the direction of the university, the bonds may be converted to a fixed interest rate, which would hold constant until the date of maturity. The university could convert the bonds to a fixed rate if interest rates were anticipated to increase. The bond holders would have the right to tender (i.e., return) their bonds to the university prior to the bonds' being converted to a fixed interest rate.

Security

The unique feature of this ARB is that it was done without a backup letter of credit. Normally, a bank letter of credit would cost annually 1/2 percent to 1 percent of the principal balance. The university was able to receive an AA rating and sell the issue because it pledged to maintain unrestricted assets at $37 million. Therefore, the university reduced its net interest cost as compared to similar issues.

SOURCE: Coopers & Lybrand.

APPENDIX I: DEBT FINANCING INSTRUMENTS

Applicable	Financing		
Institution	Range	Term	General Description
Leasing			
Private college or tax-exempt foundation	$100,000 to $1,000,00	Short-term 1-10 years	Leasing is considered a long-term rental agreement in the form of operating lease or capital lease.
Municipal Leases			
State	$100,000 to $1,000,000	1 year	A municipal lease is considered a conditional sale lease where the payments are scheduled like a lease but the lessee is considered the property owner at the lease inception. The lessor receives tax-exempt status on the interest portion of the lease payment. This form of debt is used when the entity (state, municipality, or state university) is precluded by state law from entering into debt for a longer period than a single fiscal year.

Advantages	Disadvantages
Institution acquires the use of equipment without making a substantial initial cash outlay.	If the institution has substantial capital needs and can issue debt, long-term financing would be more cost effective than leasing.
Leasing provides a means for financing small equipment acquisitions.	
Lessee has some protection against equipment obsolescence.	Leasing requires trade-offs to be made on whether the institution acquires title to the equipment.
Off the balance sheet debt.	
Quick and easy form of financing.	Leasing is another form of debt which will have an impact on the institution's cash flow.
Short-term financing with annual renewal options allowing for long-term financing as needed.	Lessors consider municipal leases risky because the government is legally committed only for a single fiscal year. The lessor will charge more to cover the risk of cancellation.
Leasing provides some protection against technical obsolescence of the equipment.	

Applicable Institution	Financing		General Description
	Range	Term	
Line of Credit			
State or private university or foundation	$1-15 million	1 to 5 years	Represents an assurance by a lending institution that funds will be made available as specific project needs arise. A university establishes a line of credit agreement with a bank, defining the terms, conditions, and interest rate to be required before an actual loan is made. The agreement states the aggregate ceiling of the loans to be outstanding at any one time.
Pool Revenue Bonds			
State or private institution	Minimum $5 million	10 years	Offers tax-exempt bond financing to a group of colleges and universities to finance numerous small projects. Two types of bond pools: blind pools do not identify the individual borrowers or the projects; composite pools identify all participants and projects and loan amounts to be included in bond issue.

Advantages	Disadvantages
Insurance of funds availability against likely but uncertain needs.	Administrative cost and time required to review loan request and monitor debt repayment.
Ability to debt finance low-priced equipment on more favorable terms than leasing.	Risk that the debt repayment guarantees of dept. heads and principal investigators will not be honored.
Ready access to funds so that equipment procurement is not delayed until grant or contract funds arrive.	
Availability of funds until permanent debt financing can be secured.	
Insurance of funds availability if unexpected needs develop.	
Institutions are able to pool their capital needs when institutions have insufficient capital needs to make an individual	Pool Revenue Bonds have the same disadvantages as revenue bonds.

Applicable Institution	Financing		General Description
	Range	Term	
Pool Revenue Bonds (continued)			
			The bonds are issued by a state educational authority, which disburses the bond proceeds to participating colleges and universities. While the authority holds the bond proceeds until the institutions need funds, the authority may invest the funds at a higher interest rate than the bond interest rate. The net interest income earned on available funds is used to partially cover administrative cost. The IRS requires that all bond proceeds be disbursed to pool participants within three years.
			The period of the institutions' loans range from three to ten years but cannot exceed the term of the bond issue.
			The financial liability of the participating institutions is limited to the amount of their individual loan agreements.

Advantages	Disadvantages
revenue bond cost effective or an institution does not have a credit rating to issue debt on its own. Allows smaller institution access to tax-exempt debt financing. Spreads the cost of issuance among a number of institutions.	If sizable debt reserves and insurance premiums are required to protect against the risk of loan defaults, the more creditworthy institutions in the pool may be subsidizing the cost of debt for the less creditworthy institutions. The financially stronger institutions may be able to obtain lower interest rates through individual bond issues and may not wish to participate in the pool.

Applicable	Financing		
Institution	Range	Term	General Description
Pool Revenue Bonds (continued)			
			The individual institution's interest rate may vary per loan agreement with the authority to properly reflect differences in loan risk between a financially strong institution and a small college.
Tax-Exempt Variable Rate Demand Bond (VRDB)			
State or private university with the assistance of government authority	Minimum $3 million	Nominal maturities of 25-30 years	Bond carrying a floating interest rate which is set periodically to a percentage of prime interest rate or treasury bills. The bond is priced as a short-term security with a nominal long-term maturity.

Advantages	Disadvantages
Provides the university access to lower interest rate debt instruments. Raise substantial funds for major projects when long-term rates are too high to issue permanent financing.	Risk and cost associated with the constant change and movement in the short-term debt market (i.e., if a bond is returned and cannot be immediately resold to a new investor, the university will have to draw on its letter of credit to repay the bond holder). Risk that the university may not be able to roll over the VRDBs into long-term debt.

Applicable Institution	Financing		General Description
	Range	Term	
Tax-Exempt Commercial Paper (TECP)			
State university or private college or foundation	Pool program minimum $50 million	TECP-270 days or less Pool program 10 years	TECP are short-term obligations with stated maturities of 270 days or less, comparable to corporate commercial paper except interest rate is tax-exempt.
	Individual loans minimum $100,000	Individual loans 1-10 years	A pool program can be established by a designated government authority which issues the TECP and lends the funds to participating institutions.
			The TECP is designed to be rolled over at its maturity without delays and additional issuance cost. The interest rates on the participating institutions' loans are determined monthly, based on the average interest rates of the TECPs sold in a month.
General Obligation			
State university	Minimum $3 million	20-30 years	Long-term bond secured by the full faith, credit and, usually, taxing power of the state or local government.

Advantages	Disadvantages
A university has access to short-term debt at favorable interest rates. Issuance costs are shared by all participants. Because the TECP has a short-term maturity and is continually rolled over, the university is not locked into long-term debt and can repay anytime without penalty.	For major, long-term project to fund, a Revenue Bond or another long-term debt instrument would match the useful life of the asset. For less cost a university with an established credit rating may be able to access short-term financing through a line of credit.
Favorable credit ratings can be obtained for the issue because it is backed by the state or local government.	Legislative approval is required for the bond. If approval is delayed, project would have to be delayed or postponed.

Applicable Institution	Financing Range	Term	General Description
Revenue Bonds			
State university or private university or college or tax-exempt foundation	Minimum $3 million	20-30 years	Long-term bonds issued to finance a specific revenue-generating project. The bonds are secured either by the project's revenue or the revenue of the institution as a whole. For a private institution to use revenue bond financing, the institution must obtain the assistance of a county, industrial development authority, educational facilities authority, or similar agency. The bond investor will look at the institution's overall revenue-generating capability as a means of assessing its ability to meet interest obligations and principal payments. State requirements vary on the authority state universities have in issuing revenue bonds.

Advantages	Disadvantages
Revenue bonds are cheaper than any form of commercial financing because interest to revenue bond investors is exempt from federal taxes.	The high issuance, legal, and brokerage fees associated with bonds mean that a substantial dollar amount is necessary to make the bond cost effective.
	The Revenue Bonds are direct obligations of a state university or college with the bond holders' looking to the university (not the state) for repayment of principal and interest.
	The attractiveness of revenue bonds is influenced by the investor's need to protect from taxes. With any lowering of tax rates, the investor will have less need to shelter income through revenue bonds.

Applicable	Financing		
Institution	Range	Term	General Description
Industrial Development Bonds			
Private college or university or tax-exempt foundation	Minimum $1 million	20-30 years	A security issued by state, local government, designated agency, or development corporation to finance the construction or purchase of buildings and/or equipment to be leased to a private corporation (institution). The credit of the private institution is considered to be the credit backing the issue.

Advantages	Disadvantages
	As that happens, to keep attracting investors, institutions will have to offer revenue bonds with higher interest rates, which will increase the institution's borrowing cost.
	Revenue bonds are long term in nature and not appropriate for financing short-term equipment needs.
Industrial Development Bonds provide private institutions a means of raising substantial capital.	The Industrial Development Bonds have the same disadvantages as revenue bonds.
Industrial Development Bond interest is also exempt from federal taxes.	

Applicable Institution	Financing Range	Financing Term	General Description
Certificates of Participation			
State or private universities	Minimum $1 million	Life of asset	Certificates of Participation are similar to On Behalf of... leases except there is no third-party guarantee. The purchaser of the certificates has an interest in the equipment lease. The certificates represent a lien on the asset.
On Behalf of...			
Tax-exempt foundation	Minimum $1 million	Life of asset	Third-party guaranteed revenue bonds or leases issued by a foundation on behalf of a state or private institution. Title to equipment is held by the foundation and passes to the institution when the debt is retired.

Advantages	Disadvantages
Institutions that do not have tax-exempt foundations can issue the certificates. Institutions are able to finance large dollar value equipment through public securities investors at longer terms and at lower interest rates than other debt instruments require.	Institutions will have to plan for the annual funding of the certificates as a fixed obligation. The purchaser will look to the institution's revenue-generating capability to meet this fixed obligation and assess his risk position.
Debt does not affect the university or college's balance sheet. Lease would be on a year-to-year basis with annual renewal. State institutions which need legislative approval for Revenue Bonds can use On Behalf of... financing without state government approval. The foundation funds and enters into the long-term lease.	On Behalf of... financing is viewed as an indirect obligation of the institution. Investors will look to the institution's revenue-generating capability to assess the risk of the issue.

SOURCE: Coopers & Lybrand.

APPENDIX J: EXAMPLES OF EQUIPMENT DONATIONS

Examples 1 through 11 below describe equipment donations involving 14 universities and 12 corporations. Equipment donated includes computed axial tomography scanners, digital fluoroscopes, nuclear magnetic resonance spectrometers, mainframe computers, microcomputers, software, oscilloscopes, spectrometers, laser units, processing equipment for very large-scale integrated circuitry, computer-aided design systems, and semiconductor manufacturing equipment.

EXAMPLE 1

Circumstances of Donation

- Principal investigators contacted research colleagues at the corporation.
- The university faculty had produced innovative ideas; these were then licensed to the donor and developed into successful products.
- The university was viewed as a recruiting source.
- The university would be used to market the donor's equipment; principal investigators would be requested to show equipment to potential purchasers; results of equipment usage would be provided for trade and scientific shows.

Special Considerations

- The donor receives license for any marketable research; the university receives the copyright. The donor must sublicense upon request; both share the royalties from sublicenses.
- The donor expects the marketing activities to be performed.
- In order to have time to obtain patents, the donor has occasionally requested that scientific results be withheld from publication. Although university guidelines provide that publication can only be withheld for 90 days, the university often complies with the request.

Institution's View

- The donation of equipment was seen as the only feasible alternative, since the level of funding necessary for such specialized machinery is unavailable through the National Institutes of Health.
- The equipment is generally high level, although not top-of-the-line.
- The donor has paid all maintenance costs.
- Students have developed the necessary software. The donor has provided an on-site programmer.
- The donor's equipment has been compatible with other equipment. Major items were self-contained.
- The equipment has worked well.
- The researchers feel that the promotional activity is an imposition.
- Patent-related issues have been problematic.

Corporate View

The donor has been happy with the university's work.

EXAMPLE 2

Circumstances of Donation

- University faculty and corporate counterparts had professional contacts prior to the donation.
- The university has an active research faculty that has pursued innovations.
- The university is attractive to corporations because of its accomplishments and innovative ideas.
- Corporations are interested in recruiting university students.
- Tax incentives have made contributions even more attractive.

Special Considerations

- A license to patentable inventions may be made available to the donor.
- There are no restrictions on the publication rights of work undertaken by the university.

Institution's View

The donor does not cover all costs. Researchers believe that they are more motivated to use the equipment if there is some cost to them. Maintenance costs, however, are quite high.

Corporate View

The university is very attractive because of its faculty, programs, and record of success.

EXAMPLE 3

Corporation View 1

- Relationships were established among university development office, department heads, researchers, and corporate counterparts.
- The university identified the equipment that was already available, plans for using the equipment, the potential users of the equipment, and their areas of interest.

Corporation View 2

- The corporation had announced its intention to assist university programs similar to that at the university; there was no previous relationship with the university.
- The corporation's program was focused on a specific area of engineering; the university had one of the country's first engineering schools in this field.

General Corporate View

- Donors were interested in exposing future users to state-of-the-art equipment.
- The tax benefits have not been a primary incentive to small companies.
- Excess inventory resulting from lower sales has been a minor factor.

Special Considerations

No special considerations were identified.

Institution's View

State-of-the-art equipment is now available, although maintenance and technical support costs are a problem. For this reason, not all equipment that is offered is accepted.

EXAMPLE 4

Circumstances of Donations

- For research and development purposes, faculty members and department heads work through corporate contacts to obtain contracts.
- The university has had limited success with sending letters to organizations with no prior contact. Often, the corporation may like something about the program being undertaken, and this will provide a floor for establishing a relationship.
- With scientific equipment, personal contacts are very important. The foundation and development officers will help faculty members and department heads develop plans to inform corporate representatives about proposed projects.
- Scientific equipment is almost never given in isolation. Generally, the university has developed a program that the donor is interested in, and the donor will provide the equipment and money.

Special Considerations

- Scientific equipment never has any quid pro quo.
- With research and development equipment, the nonexclusive use of patents is provided to the contracting corporation, and the university holds the patent. Sometimes the university will receive royalties, depending upon the arrangement.

Institution's View

- Since the donor does not cover all costs, maintenance and operating costs are a major problem.

- The university generally has been happy with the arrangements.

Corporate View

The donating organization appears to be pleased with the way the arrangements have worked out.

EXAMPLE 5

Circumstances of Donation

- The university has a good reputation in many scientific areas.
- The donors receive feedback on prototype equipment to work out bugs.
- The university has productive relations with contributors, which leads to many coming back repeatedly.
- The university faculty conceives interesting projects and establishes personal contacts with donors.
- Tax benefits are helpful but are not a major factor.

Special Considerations

- Certain corporations give many micros to faculty, and there is an agreement to share any software developed. The university has the copyright, but the donor often has exclusive license.
- The donor expects feedback on prototypes.
- There are sometimes restrictions on publication for up to one year, which must be complied with (does not normally cause problems).

Institution's View

- The university is generally happy.
- Often the maintenance costs are covered by the donor.
- Many corporations come back many times.
- Sometimes they are offered more equipment than they can take. They only accept it when it is well matched to their needs.
- They get a good deal of state-of-the-art equipment and prototypes.

Corporate View

There was no specific feedback, but the university assumes they are satisfied since they keep returning.

EXAMPLE 6

Circumstances of Donations

Corporate

- Corporations are interested in exposing future users to state-of-the-art equipment.
- Corporations seek researchers' feedback in order to improve equipment.
- Corporations donate equipment to demonstrate general support for higher education.

University

- The university strictly enforces the conditions under which it will accept gifts: exclusive licensing arrangements are never provided; nonexclusive agreements are acceptable.
- The university will not provide the donor with written feedback; however, oral discussions are acceptable.

Special Considerations

- Donor corporations often contribute ancillary expenses such as maintenance and software along with the equipment.
- Both the university and the corporations initiate contacts. Corporate contacts are developed through visiting committees and other visits by corporate executives and researchers. Individual faculty members develop relationships with corporate counterparts.

Institution's View

Generally, the university has been able to obtain whatever equipment has been needed.

EXAMPLE 7

Circumstances of Arrangements

- Money is primarily given under research contracts. Equipment is supplied if it is needed.
- Contacts are often made through established relationships with universities.
- One university is a popular donee since many alumni work at the corporation.
- Arrangements are often entered into when an institution has begun working on a program in which the corporation is interested.
- Tax benefits have a significant impact on the level of contributions.
- The corporation feels an obligation to help fund university research since more is needed. It cannot fund the amounts it would like to because of the costs. Additional tax benefits would be a desirable way of lowering costs.

Special Considerations

The corporation installs the equipment and for awhile maintains it and provides backup support.

Institution's View

It appears that colleges are satisfied with the arrangements.

Corporate View

Results have been good so far. If they had not been, the corporation would not continue contract research and scientific equipment donations.

EXAMPLE 8

Circumstances of Donation

- The corporation ordinarily makes a grant after a written proposal is submitted; proposals come about as a result of continuing dialogue with university researchers.

- Considerations include the corporation's desire to support education; the quality of the institution, its faculty, and its students; its ability to undertake proposed projects; its fiduciary capability; and the importance to the corporation of the technology under study.
- Ordinarily, R&D expenditures are joint study contracts under which the corporation provides money, equipment, and personnel.
- The R&D tax credit is an incentive for the corporation (1) in making positive decisions on marginal projects, and (2) because credit ameliorates impact on after-tax profit margins of increased R&D spending.

Special Considerations

- No conditions or restrictions are placed on the institutions to which it provides grants of equipment.
- Maintenance contracts are usually provided for the warranty period, after which the institution must absorb the cost.
- The corporation is flexible in structuring research contracts, but its primary concern is access to results; no restrictions are made as to use or publication of results.

Corporate View

- The corporation looks for institutions with necessary technical know-how to perform a project.
- Success of projects is viewed in broad terms. Any advancement of the knowledge base in a particular area is considered a success.

EXAMPLE 9

Circumstances of Arrangements

- Primary motivation of contributions is to help upgrade university research facilities, since many are outdated.
- The corporation hopes to provide well-trained engineers in the fields the corporation is interested in with the hope that there will be a supply of good engineers for future hiring.
- Corporations also make donations with the hope that users will be happy with them and purchase additional products of those corporations.

- Tax incentives are important regarding the level of charitable contributions. This is because the higher the percentage of product cost that can be offset with tax benefits, the greater the number of products that can be donated at the same cost.
- Equipment donations are initiated by colleges interested in obtaining a product and by a corporation when it identifies institutions that are performing research in areas it is interested in. Contacts between the corporation and the institutions have been in existence prior to some contributions, although this is not true in a large number of instances.

Special Considerations

- Equipment is not usually provided under research contracts, which are normally with large research institutions. The reason for this is that when the corporation enters a research contract, it does not have adequate personnel on hand to do the work itself; it looks for colleges or universities with facilities in place in the particular field of study and specialized personnel.
- Basic research contracts are not often entered into, since they will not necessarily provide the corporation with any direct benefits and they are difficult to justify to shareholders. Also, since a fair amount of basic research is performed at the corporation in fields it is interested in, it has less of an incentive to fund basic research elsewhere.
- When a corporation donates equipment, it also installs it and provides the same warranty a paying customer receives. If a service contract is ordinarily provided with the equipment, that is also included. Corporations would be more willing to provide service contracts if additional tax benefits were associated with them.

Corporate View

- The corporation expects colleges to take some responsibility for operating and maintaining the equipment and does not feel that it should incur all costs.
- The corporation has an interest in seeing the property maintained, because if students repeatedly observe the equipment malfunctioning, they will develop a negative image of it and will be less likely to purchase it in the future.

EXAMPLE 10

Circumstances of Arrangements

- Primary concerns are with expertise of the institution and its ability to assist with product application and development.
- Tax incentives make scientific contributions and research contracts more desirable.
- Arrangements result from informal contacts between corporate and university counterparts.

Special Considerations

- There is no quid pro quo for contributions of scientific equipment, although access to data regarding equipment use is anticipated.
- If research produces any patentable results, the corporation acquires a license.

Institution's View

Generally there is a favorable perception. If institutions were not happy, they would not continue to accept equipment and undertake research arrangements.

Corporate View

Favorable feedback has been received. There was only one instance where an arrangement was not considered successful.

EXAMPLE 11

Circumstances of Donations

Research and Development

- In the case of research and development projects, the company is mainly looking at what it can receive in return, such as technology that can be marketed or put to use in-house for designing new products (e.g., software).
- Marketing of equipment is also important in the hope that (1) institutions will purchase additional equipment from the

donating company, and (2) that students' experience with the equipment will encourage future sales.

- Receipt of proposals in which the company is interested and a proven capacity to conduct high-quality research are influential in decisions to donate equipment for R&D contracts.
- Tax benefits are helpful in the decision to donate.

Scientific Equipment

- Tax benefits are important in the decision to donate. The company prefers to donate more expensive items, since there is a higher markup and they can take advantage of scientific equipment deductions.
- Major contributions were made to one institution for the following reasons: the company could not enter into an R&D contract, since the university will not provide exclusive rights to anyone; informal feedback is useful to the company regarding equipment performance; the institution has a good research reputation; close personal ties have developed over the years, since many high-level employees are graduates of that university; and since the company's engineers will be working on the equipment with that university's counterparts, the company will have first-hand knowledge of the information being developed and its possible uses (the type of work the equipment is being used for is important to the company).

Special Considerations

- The university holds the copyright or patent, but the company has nonexclusive license with no royalty payments to the university.
- The company has the right to review material before it is published to ensure that no proprietary information is released.
- No special considerations are involved for scientific equipment contributions. The equipment is given outright without restrictions.

Institution's View

The company was not aware of any specifics.

Corporate View

The company is happy with the past record of a number of institutions. It has recently dramatically increased the level of contributions and has not yet received the results of most new projects.

SOURCE: Coopers & Lybrand.